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# **SMALL-MEDIUM ENGINEERING ENTERPRISES AND E-BUSINESS**

## **Executive Summary**

*Submitted in Partial Fulfilment for the Degree of Doctor of Engineering*

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## ABSTRACT

A preferred methodology for handling increasing customer demands and the resulting complexity is to design common modules or subsystems. The design of all the modules required by a complex system, such as a car, aeroplane or computer, is increasingly a task beyond the organisational resources of the OEMs and their close suppliers. Therefore, a larger burden is transferred down the supply chain. As a consequence, lower tier suppliers are required to play a more proactive role and demonstrate an appropriate breadth of skills and resources in order to provide complete sub-systems. This research focuses on collaboration and e-business for a solution which will enable engineering SMEs to respond to such challenges and undertake higher value projects. In particular, the aim of this engineering doctorate is to develop and implement a mechanism that puts together combinations of SMEs with the required capability, within an e-business environment.

Accounting for 99.3% of all manufacturing companies and 50.8% of the total employment, SME prosperity and 'well-being' has significant impact on the national economy. Analyses, such as these provided by KPMG and PriceWaterhouseCoopers, indicate that the demand for common components could substantially reduce the number of small manufacturers and subcontractors. Statistics published by the Office of National Statistics (ONS) confirm the decline of the sector, a reduction of over 22% in overall sector turnover has been reported in the past two years.

Although, improved communication links through collaboration and 'e' enablement could permit SMEs to move towards a more enriched business model, there is evidence that e-business take-up and success in Europe among engineering businesses is low. For instance, focusing on on-line sales, the *eEurope* 2004 benchmarking report admits that only 14% of SMEs make on-line sales and in only 7% of SMEs do on-line sales constitute more than 5% of their overall sales. The vast majority of companies still continue to rely on old trusted methods of doing business even though outsourcing to lower cost regions and countries is a major threat to many engineering SMEs in Europe.

Access to specific competences drives organisations to collaborate with each other. Focusing on the organisational competence, a notion which expresses the key skills and capabilities of an organisation, an ICT based methodology has been developed and tested in this research. The 'Competence Profiling Methodology' facilitates collaborative business processes. The methodology enables the discovery of appropriate collaborators for the development and manufacture of complex systems by matching complimentary competences and softer factors.

These ideas were developed and tested within two SME projects in the West Midlands, Autocle@r and Autolean 3, as well as with the DTI funded Manufacturing Advisory Service – West Midlands, a one-stop shop to assist manufacturing SMEs. The results from these projects were used to develop a practical portal architecture, to help e-enable engineering SMEs. The resulting West Midlands Collaborative Commerce Marketplace, has over 2000 SME members, has had over 40,000 tenders through the system and over 100 companies are using collaborative spaces to coordinate resources.

A key conclusion of this research is that traditional e-business is poorly suited to engineering SMEs being very standard product orientated. Skills and capabilities are far more generic than end products and focusing on them can support more effective e-enablement of engineering companies. Results from the WMCCM ([www.wmccm.co.uk](http://www.wmccm.co.uk)) project confirm this.



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# **LIST OF ABBREVIATIONS**

2WM:	2WestMidlands
APF:	Associate Profile Form
ARICON:	Assessment of Readiness and Interoperability for Cooperation in New Product Development in Virtual Organisations
CEM:	Centre of Expertise in Manufacturing
CIM:	Computer Integrated Manufacturing
CPF:	Competence Profiling Facility
CPQ:	Competence Profiling Questionnaire
CPM:	Competence Profiling Methodology
DDA:	Defence Diversification Agency
DTI:	Department of Trade and Industry
e-Business:	Electronic Business
ECOLEAD:	European Collaborative networked Organisations LEADership initiative
EDI:	Electronic Data Interchange
Engineering SME:	Small-Medium Engineering Enterprise
EPM:	Expertise Profiling Methodology
GDP:	Gross Domestic Product
GOWM:	Government Office West Midlands
HEI:	Higher Education Institutes
ICT:	Information Communication Technology
ILO:	Industrial Liaison Officer
IMECHE:	Institute of Mechanical Engineers
IP:	Intellectual Property

IPSE:	Institute for Promotion of Small Enterprises
MAS:	Manufacturing Advisory Service
MAS-WM:	Manufacturing Advisory Service - West Midlands
MDA:	Mobile Data Association
NDI:	Northern Defence Industries
OEM:	Original Equipment Manufacturer
OJEC:	Official Journal of the European Communities
ONS:	Office for National Statistics
OSI:	Operational Standard Identification
RCME:	Regional Centre for Manufacturing Excellence
SMS:	Short Message Service
WMCCM:	West Midlands Collaborative Commerce Marketplace
WMG:	Warwick Manufacturing Group
WWW:	World Wide Web
XML:	eXtensible Markup Language

## DECLARATION

I, Nikolaos Armoutis hereby declare that all the work presented within this Executive Summary was undertaken personally unless otherwise acknowledged within the text, and that none of the work has been previously submitted for any other academic qualification that has not been authorised by the University.



## 1. Introduction

The research described in this document focuses on small-medium sized engineering enterprises (engineering SMEs), and how they can develop in response to business pressures using the opportunities provided by the Internet. Studies, such as these carried out by the European Union's Enterprise Directorate General (EDG, 2004; Perogianni, 2003), have clearly shown that the benefits for Small and Medium Enterprises (SMEs) can be very significant. The Internet "can help SMEs to access new markets, find new business partners and benefit from lower prices and increased choice" (Perogianni, 2003: p5). A report by Cisco has quantified the scale of the benefits that can be achieved. Early adopter SMEs have experienced increases in revenues of nearly 75% on average, and reduced costs by 50% as a direct result of their use of Internet technologies (Cisco, 2001a). Although practical evidence indicates significant benefits are possible, statistics prove that the majority of SMEs are not profiting from the Internet. For instance, focusing on on-line sales, one of the means to SMEs to benefit from the Internet, the 'eEurope 2004' benchmarking report admits that only 14% of SMEs make sales on-line and in only 7% of SMEs do on-line sales constitute more than 5% of their overall sales (EDG, 2004).

The work conducted for this Engineering Doctorate (EngD) provides a foundation for engineering SMEs to exploit the benefits the Internet can offer. It recognises that the current on-line solutions do not address adequately the real needs of engineering SMEs, nor do they address the trust and confidence issues between engineering trading parties. Research by PriceWaterhouseCoopers (2002a) has indicated that businesses are using e-business mainly to communicate more effectively with suppliers they already know. Only

22 % of companies purchasing on-line choose new suppliers. However, it is increasingly recognised that gaining full benefit from e-business requires companies to transact with partners they have never met (PriceWaterhouseCoopers, 2002a; Perogianni, 2003). Therefore, it is very important for engineering SMEs to exhibit a level of confidence and trust that will encourage them to be chosen on-line. Suggesting that collaboration is really the only practical strategy open to SMEs. A mechanism which allows engineering SMEs to be located and matched on-line by potential customers or partners has been developed.

### *1.1 Background*

Manufacturing has for a long time been seen as a critical element within the UK economy. At the forefront of the early industrial revolution, the UK economy has developed a long tradition in sectors such as motor vehicles, metal products and general engineering. In 1762 Matthew Boulton built a factory in Birmingham which employed more than six hundred workers and installed a steam engine to run a variety of lathes as well as polishing and grinding machines. During the same period, in Staffordshire, an industry developed which gave the world good cheap pottery. There were many success stories in the UK during this period. These developments had far reaching economic and social impacts and established the UK at the forefront of the global economy. However, in recent years the situation has radically altered. Although manufacturing is still significant for the national economy, most analysts believe there is a substantial gap in manufacturing productivity when compared to its overseas competitors. Manufacturing makes up a fifth of the national economy, employs one in seven of the workforce, and accounts for 60% of the UK's exports. However, surveys suggest that labour productivity is 55% lower than the US, 32% lower than France, and 29% less than Germany (DTI, 2002a).



SMEs have an important role within this setting. Accounting for 99.3% of all manufacturing companies and 50.8% of the total employment (SBS, 2002), their prosperity and ‘well-being’ has significant impact on the national economy. Although selected manufacturing industries, such as oil & gas, and food processing, have strong international presence, the remaining manufacturing industries score poorly either on a national or international scale (McKinsey, 2002; O'Mahony and de Boer, 2002; DTI, 2002a; DTI, 2003a). The weak sectors cover the traditional electrical, electronic and mechanical industries. Improving the productivity and competitiveness of engineering SMEs is then of national importance. The scale of this task can seem daunting, however it is not often realised how only a few companies can actually significantly affect the overall national picture. As Colin Mynott<sup>1</sup> has identified, only 20,000 innovative SMEs support 1,120,000 other SMEs in the UK. The key task is to support these 20,000 and to increase this number.

Recognising the significance of engineering SMEs, the UK government developed a manufacturing strategy to improve the prospects of the sector. Inter-firm collaboration and the modernisation of the Information and Communication Technology (ICT) infrastructure have a key role in this strategy (DTI, 2002a). The projects undertaken in this EngD, though some of them predating the DTI strategy, are aligned with this goal.

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<sup>1</sup> At an IMECHE debate on “What is Successful Innovation” in May 2004 Colin Mynott explained the UK has about 20,000 companies that design and manufacture their own products, 120,000 manufacture components as part of a supply chain, and 1,000,000 provide additional services and support to maintain this manufacture base.

In their analysis of the UK economy, Porter & Ketels (2003) view collaboration as a crucial element in enhancing competitiveness. Collaboration enables SMEs to link their complementary competences, by joining forces SMEs could bid for larger, higher value added contracts. Combined they could reach the critical mass of resources needed to develop and produce larger more complex systems as products and migrate from selling simple low profit standard parts to selling more value added system solutions. Preiss et al (1996) has demonstrated that there is almost a linear relationship between the level of sophistication of a product and financial rewards. They reported a similar correlation between rewards and communication links with customers and suppliers. Improved communication links through collaboration and 'e' enablement could permit SMEs to move towards this more enriched business model.

Defined by the UK Department of Trade and Industry (DTI, 2000), e-business "describes how businesses are using information gathered electronically to improve their business processes and relationships with suppliers and consumers. This potentially covers all business areas, such as design, production, operations, customer service, as well as buying and selling". Although the definition indicates a wide scope for potential ICT implementations, the majority of current applications focus on facilitation for businesses that produce standardised products.

Measuring ICT adoption in SMEs, the DTI identified that on average no more than 32% of SMEs are trading on-line (DTI, 2004b). The most common reason given by UK business for not ordering or selling goods or services on-line was that the products were not suitable for on-line purchasing. This is the case for many engineering SMEs. They



provide highly customised products or ‘one-of’ jobs that cannot be represented by a list of standard parameters. Standard information such as price, product description, pictures and drawings, hardly exists, and therefore finding and comparing suppliers based on their products is extremely difficult. However, the majority of trade on-line directories such as Applegate ([www.applegate.co.uk](http://www.applegate.co.uk)), only provide contact information or standard product descriptions. The key question is, what information do engineering SMEs need to provide in order to be “found” on-line by potential customers or partners. The information provided must also generate a good level of confidence and trust, something that is very important in normal business, but of extreme importance in e-business. There is less of a need for this with “standard products” because these generally have specifications that can be easily compared.

Engineering SMEs meet customer requirements based on the abilities of their processes and their skill in operating and pushing them to the limits of their capability. One of the companies the author visited while carrying out his research, Strata (Flame Cutting & Fabrications) Ltd., provides an example of how engineering SMEs meet customer requirements. The company provided flame-cutting services. It had the appropriate skills, processes, and machinery to cut a range of sheet metal for quality tooling. Although mainly involved with the automotive industry, Strata were always open to new opportunities independently of the type of final product and market sector. For instance, the company had undertaken flame cutting projects for sculptures. It was also reported that profit margins were significantly better, almost double, in sculpture projects compared to a typical automotive tooling project.



Strata illustrates the way many engineering SMEs operate. Although normally regarded as product providers, their core business is better defined in terms of an engineering “service” based on their skills, processes and the tools or equipment they employ. This service may be offered to a specific industry and for a specific range of products. However, usually the service offered is broader based. Whether automotive machine tool or visual arts sculpture, there is no difference for many engineering SMEs as the same technical engineering abilities are required.

The focal point of an engineering company is then the key technical engineering abilities and not the physical end products. Drawing on the term ‘competence’ to describe these abilities, a mechanism to enhance confidence and trust in engineering SMEs competences is introduced in this research.

## *1.2 Research aim and objectives*

With this background, the aim of this research is:

*“to develop and implement a mechanism that supports collaboration by enabling reliable identification, comparison, and combination of engineering SMEs with the right skills, resources, and culture to tackle new opportunities within an e-business environment.”*

This aim is to be achieved by:

1. Investigating the inhibitors that prevent engineering SMEs adopting e-business successfully
2. Examining the existing methods of identifying on-line suppliers and partners in manufacturing industry and determining their key strengths and weakness

3. Proposing a mechanism to enable collaboration for engineering SMEs and facilitate e-business
4. Developing appropriate and innovative e-business based methodologies and tools based on identified requirements
5. Field testing and fine-tuning of the developed methodologies and tools through industrial applications, and in an engineering SME environment in particular

The portfolio of work undertaken has allowed the author to address these areas. This Executive Summary explains how these objectives have been met.

### *1.3 Scope of research*

Due to their importance to the national economy, discussed in paragraph 1.1, this research focuses on small-medium sized engineering enterprises (engineering SMEs). Companies in this sector are manufacturers of engineering products that supply industries such as automotive, aerospace, rail, white-goods, and mechanical machinery and equipment.

One of the early reports on Small Firms by the Bolton Committee (HMSO, 1971) defines small companies as “an independent business, managed by its owner or part-owners and having a small market share”. Although generic and not specific in numerical terms, this definition depicted key distinctive characteristics small companies have such as:

- their small market influence when considered as scattered units
- the key importance the owners have in their day-to-day running and welfare

Over the years a variety of definitions of the term SME have been provided by different organisations. The UK Companies Act 1985 sections 247 and 249 (HMSO, 2004) and the



European Commission (EC, 2003) provide the indicative definitions adopted in this research. The first defines a small-medium company as the one that has a turnover of not more than £22.8 million, a balance sheet total of not more than £11.4 million and not more than 250 employees. Similar is the definition provided by the European Commission where an SME has less than 250 employees and a turnover of not more than €50 million or a balance sheet total of not more than €43 million.

Geographically this research is mainly focused on the West Midlands region. The region is associated with traditional industries such as automotive, general engineering, jewellery, and ceramics. It contributes 8.2% of the UK's total gross domestic product (GDP), employing 2.45 million people (GOWM, 2002). Manufacturing industry employs 21.6% of the total population in employment and accounts for approximately 29% of the region's GDP, the largest share of any region in the UK (GOWM, 2002; DTI, 2002c). Its significance has attracted government attention especially after the recent rapid closure of the Rover Group. Due to the recognised vulnerability of the automotive sector, the government has highlighted the need for modernising and diversifying the economic base. The UK government has attempted to strengthen the economy through several initiatives such as "UK online-for-business", university innovation centres, such as the National B2B centre at Warwick University, and the establishment of Business Links and the regional Manufacturing Advisory Services. Due to this significance as well as the engineering relevance, the West Midlands was considered an excellent research field for this engineering doctorate. The results obtained could also be applicable to other regions with similar socio-economical characteristics. For example, largely classified as a European 'objective 2' industrial area, West Midlands has socio-economic commonalities with other

objective 2 industrial European regions and hence the results obtained here have broader validity.

### *1.4 Statement about innovation*

The core novel features that this research brings in the application of knowledge to the engineering business environment are summarised in the following two points:

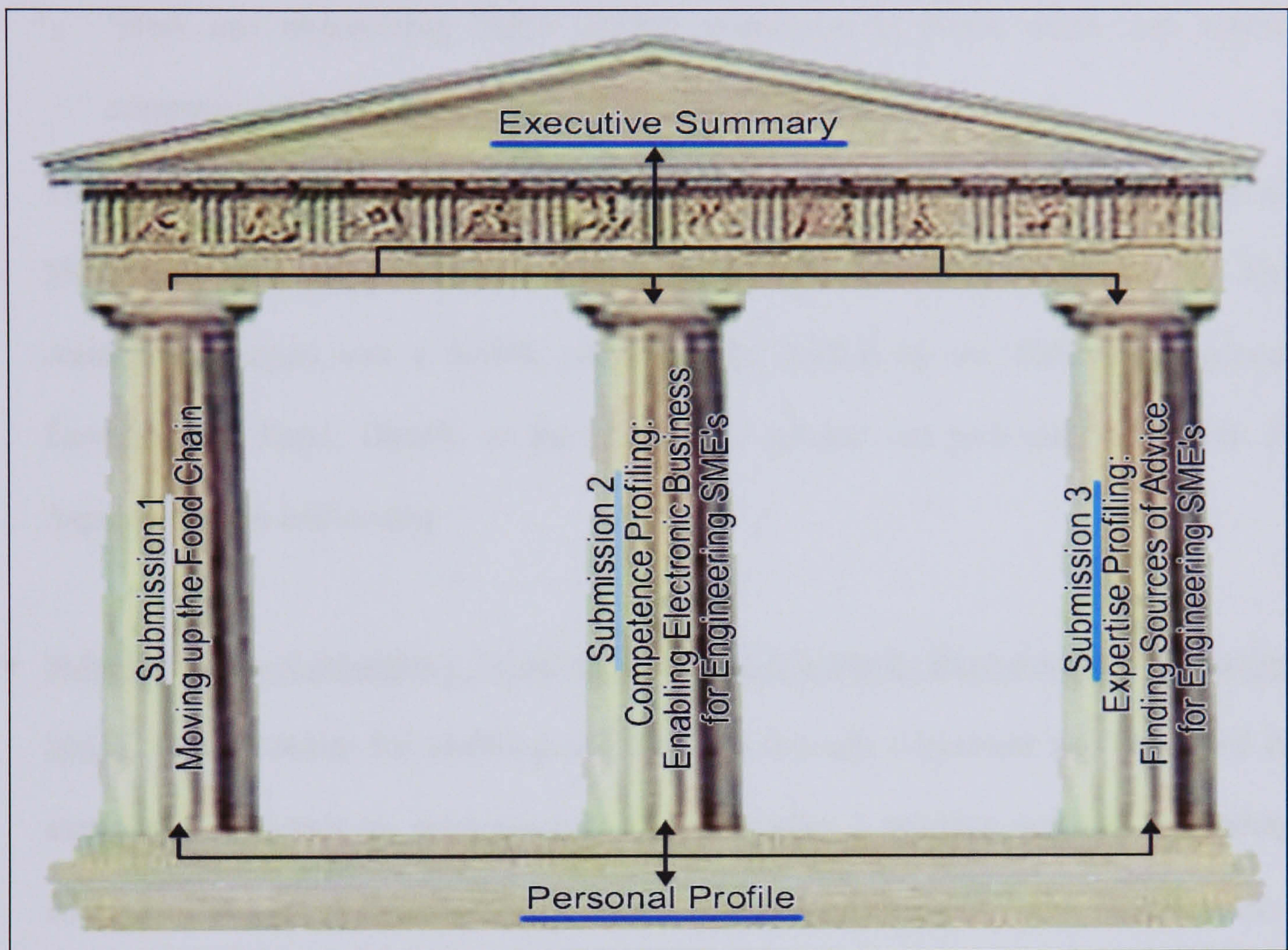
- A web-based methodology for finding and appraising engineering SME has been developed and tested that focuses on competence rather than products. Web-based methods such as the one suggested by Camarinha-Matos et al (1999) and even major e-business adoption methodologies, such as the one proposed by Fingar et al (2000), are focused on end products and not on the factors that enable engineering companies to build products.
- The methodology supports collaboration by enabling matching of competences and suggesting a group of complimentary companies based on user preferences. Other web-based methods proposed by authors such as Akarte et al (2001) are mainly focused on ranking and final selection of a supplier. Industrial portals and e-marketplaces, such as the Supply-On ([www.supplyon.com](http://www.supplyon.com)), are limited to company searching without enabling matching competences and suggesting a group of companies, virtual organisations, to undertake a project.

### *1.5 Portfolio structure*

Inspired by ancient Athens in Greece, the author's place of origin, the portfolio structure for this Engineering Doctorate (EngD) is represented by the ancient Greek temple of Athena (*Figure 1*). Athena, an ancient Greek goddess of wisdom and craftsmanship, remains a symbol of knowledge, good reasoning and manufacturing which are all key



themes to this work. In the ancient Athena temple of *Figure 1* the black arrows indicate the information flow and the colour of the underline matches with the colour of the cover pages of each of the documents.



**Figure 1 EngD portfolio structure**

- The Personal Profile forms the foundation of the EngD program. It describes the development of the author's personal competences and the mastery of the required competencies, achieved through the project work and modules undertaken, is demonstrated. A summary of personal competences developed including a discussion on the way the author fulfilled the requirements of the EngD program are provided in *Appendix 1*.



- Submission 1 - Moving up the Food Chain. This submission describes the early goal of this research, “To move SMEs up the food chain”. It investigates the challenges facing SMEs, the options available to them and identifies “collaboration” as an important lever to enable this. An initial overall research question was also proposed. This was:
  - ‘How can engineering SMEs exploit e-business to obtain work and sustain competitiveness?’

The ideas presented in this submission were generated during the undertaking of an SME development project in the West Midlands, the ‘Autocle@r’ project. The Autocle@r project was a £400K project partly funded by the European Regional Development Fund. Details of the Autocle@r project are provided in section 5- *Implementation and testing*.

- Submission 2 - Competence Profiling: Enabling Electronic Business for Engineering SMEs. A mechanism for enabling collaboration through e-business was identified as extremely important by submission 1. In submission 2 existing methods of finding sources of supply in manufacturing were examined. From these a new methodology, the Competence Profiling Methodology (CPM) was developed which, in contrast with other approaches, highlights what engineering SMEs are able to do instead of just focusing only what they currently do, i.e. their end products. Applying this methodology, a semi-automated system for suggesting partnerships based on a range of hard and soft factors was developed. The ideas developed in this work have been tested within the Autocle@r project as well as the £200K ‘Rover Task Force’ project, Autocle@r 3 (see section 5 *Implementation and testing*).

- Submission 3 – Expertise Profiling: Finding Sources of Advice for Engineering SMEs.

Building on the success of the work undertaken for the Autocle@r and Autolean 3 projects, a variation of the Competence Profiling Methodology was devised and applied for finding sources of advice for manufacturing SMEs. The work described in this submission addressed the requirements of the then newly established Manufacturing Advisory Service – West Midlands (MAS-WM), a £3.2 million DTI initiative to provide manufacturing SMEs with practical help with new manufacturing technology and best practice (see section 5.4 *Expertise profiling: Finding sources of advice for engineering SMEs*).

- Executive Summary. This sets all the submissions in the context of the engineering SME environment and summarises the achievements and lessons from the work undertaken. It also provides an opportunity for:
  - Describing changes and developments that have occurred since the submitted work
  - Emphasising the innovative aspects of the work
  - Describing follow on work based on ideas derived in this research
  - Viewing the work in hindsight and providing overall conclusions

The portfolio also contains the published papers, a transcript and results for post module assignments of the taught modules attended by the author. Although these documents provide significant evidence of contribution to competence development, they are not always directly related with the project work undertaken which this Executive Summary concentrates on. More details on them are provided in the ‘Personal Profile’.



## 1.6 *Suggested order of reading*

The ‘Executive Summary’ followed by the ‘Personal Profile’ are recommended by the author as the first documents to be read. The suggested order of reading of the submissions in this EngD portfolio follows the natural flow of the work done (*Figure 1*). As evidence of planning and project management, submissions were made at regular intervals throughout the EngD program. Each piece of project work was submitted into the portfolio towards the end of each of the key five applied research projects the author participated in. These five projects were:

1. Autocle@r, discussed in section 5 - *Implementation and testing*
2. Autolean 3, discussed in section 5 - *Implementation and testing*
3. Manufacturing Advisory Service – West Midlands (MAS-WM) discussed in paragraph 5.4 - *Expertise Profiling: Finding sources of advice for engineering SMEs*
4. West Midlands Collaborative Commerce Marketplace functionality definition and system implementation, discussed in paragraph 5.3 - *The West Midlands Collaborative Commerce Marketplace (WMCCM)*
5. Northern Defence Industries evaluation, discussed in paragraph 5.2.2 - *The Northern Defence Industries (NDI)*



## 2. Research methodology

Born in a family that owned and operated a small clothing manufacturing business, the author developed interest and empathy towards the engineering SME environment. This interest and empathy led to him being enthusiastic towards actively researching the engineering SME environment by engaging himself and developing his own perception and appreciation of the industrial engineering development culture. It was his belief that by having an active role within what was being researched would enable him to gain an insight of the phenomena within the context of real life and therefore develop innovative and industry applicable solutions. It was also his belief that he would be able to develop a variety of personal competences, such as teamwork and leadership, which would be of key significance to his career. This belief reflected the overall research paradigm that this research was closest to. This was the ‘phenomenological’ paradigm which in contrast to the other key paradigm, ‘positivistic’, advocates perception of reality through direct experience (Sherman and Webb, 1988; Hussey and Hussey, 1997).

The adoption of a paradigm has key implications for the research methodology. It predisposes key features of the research methodology (Hussey and Hussey, 1997). In *Table 1* the key features of the positivistic and phenomenological paradigms are shown. In addition, although there is no strict categorization, different types of research methods lend themselves more to one paradigm than another (Hussey and Hussey, 1997; Blaxter et al., 2001). For instance, in contrast with experimental studies, action and case study research are regarded as being closer to the principles served by the phenomenological paradigm.

**Table 1 Features of the positivistic and phenomenological paradigms**

(Source: Business Research (Hussey and Hussey, 1997))

<b>Positivistic paradigm</b>	<b>Phenomenological paradigm</b>
Tends to produce quantitative data	Tends to produce qualitative data
Uses large samples	Uses small samples
Concerned with hypothesis testing	Concerned with generating theories
Data is highly specific and precise	Data is rich and subjective
The location is artificial	The location is natural
Reliability is high	Reliability is low
Validity is low	Validity is high
Generalises from sample to population	Generalises from one setting to another

The research method and research techniques utilised to support the research paradigm in each of the research phases are shown in *Table 2*. In each submission a more detailed description and justification of the methods utilised is provided.

‘Case studies’ was the main method employed in this research. According to Yin (1994), there are three conditions for using case studies:

1. Research questions are of ‘how’ and ‘why’ type, or ‘what’ questions that are exploratory. These types of research questions are more likely to lead to case studies.
2. The investigator is not required to have control over actual behaviour events.
3. The study focuses on contemporary events.

Considering that the key research question of this research is ‘how engineering SMEs can be reliably identified, compared and combined within an e-business environment by potential customers or partners’, the first condition for a case study research is met. This question is of an exploratory nature which according to authors such as Hussey and Hussey (1997) and Yin (1994), is aligned with case study research. It leads to the development of related propositions for further inquiry, such as the functions of a Competence Profiling Methodology.



Table 2 Phases, methodology, and methods utilised in this research

Research Phase	Research Method	Data	Research Techniques	Activities
Reviewing the field (documented in submissions: 1, 2, and 3)	Case studies		<ul style="list-style-type: none"><li>• Documents</li><li>• Searches on the Internet</li></ul>	<ul style="list-style-type: none"><li>• Bibliographical research such as library books, article in journals-magazines-newspapers, conference papers, governmental reports, project reports, published statistics, electronic databases (e.g. Pro-Quest Direct, EBSCO), the Internet</li><li>• Experts’ opinion (e.g. the MAS National Network Developer T. Boylan)</li><li>• Visits to exhibitions, conferences (e.g. Softworld Supply Chain)</li></ul>
Competence Profiling Methodology development (documented in submissions: 2)		20 Autocle@r SMEs	<ul style="list-style-type: none"><li>• Documents</li><li>• Observations</li><li>• Laboratory work</li></ul>	<ul style="list-style-type: none"><li>• Bibliographical research to provide working definition of the term ‘competence’ and clarification of other terms and concepts used in questionnaires as well as to acquire skills, such as programming in ASP, essential in the development stage</li><li>• Programming (website and database development)</li><li>• Visits to SMEs</li><li>• Experts' and users’ feedback (e.g. the creator and organiser of the IMECHE Awards for Manufacturing Excellence, Dr J. Garside)</li></ul>
Competence and Profiling Methodology testing (documented in submissions: 2, 3 and Executive Summary)		20 Autocle@r SMEs, 62 Autolean3 SMEs, Manufacturing Advisory Service – West Midlands (MAS-WM), Advantage West Midlands, Northern Defence Industries	<ul style="list-style-type: none"><li>• Laboratory work</li><li>• Documents</li><li>• Questionnaire, Interviews</li></ul>	<ul style="list-style-type: none"><li>• Bibliographical research</li><li>• Interviews based on the Competence Profile Questionnaire</li><li>• Storage of collected data into the databases</li><li>• Experts' and users’ feedback (e.g. J. Robson from CONTACT)</li><li>• Refinements of the Competence Profiling Methodology</li></ul>
Reflecting and integrating (documented in the Executive Summary)		West Midlands Collaborative Commerce Marketplace (WMCCM)		<ul style="list-style-type: none"><li>• Commercial spin-offs</li><li>• Writing submissions, presentations, and publications</li></ul>

As far as the second condition is concerned, there was no need for control over behavioural events. Causal relationships are examined mainly in structured experiments where the researcher systematically and precisely eliminates certain variables or keeps some variables constant in order to identify any effects on others. In contrast, the author was seeking to assess the natural behaviour and evaluate the effectiveness and the benefits of each application. This is linked with Yin's third condition as it indicates a direct observation and examination of the applications, which could only be made on contemporary events.

Similar to case studies, action research is based on the assumption that the social world is constantly changing, and the researcher is part of this change. As described by Hussey and Hussey (1997), the main aim of action research is usually to enter into a problem an organisation faces, attempt to bring change, and finally to monitor the results. In this respect the work undertaken for the MAS-WM could be regarded as action research. The identified problem was that the existing approaches of searching and finding sources of expertise and advice for the region's manufacturing SMEs were ineffective. An attempt to bring change by introducing a new ICT based approach was made and finally the results of this attempt were monitored and analysed. The work done for the MAS-WM was one of the three cases when the concept of competence profiling was implemented, and tested. The Autocle@r, Autolean 3, and MAS-WM projects were experimental type case studies. In experimental case studies the research examines the issues involved in developing and implementing new procedures and techniques as well as the benefits gained (Scapens, 1990). This method also, in theory, promotes academic rigor and therefore is regarded more acceptable by the academic community which some times considers action research



as a client driven consultancy project (Baskerville and Wood-Harper, 1996; Avison et al., 1999; Gummesson, 2000).

### 2.1 *Research phases*

As shown in *Table 2* (page 27), the research undertaken consisted of four phases. The phases should be viewed as parts of an iterative and concurrent process rather than a sequential process. They refer to areas of work that received greater emphasis at certain stages in the process.

The “review of the field” was focused on identifying and analysing the alternative options for engineering SMEs to ‘move up the food chain’. Then it was detailed on identifying and analysing the theories and practices of supplier identification and appraisal. It provided information and ideas on how companies can be identified and appraised as well as on what information is required for the effective representation of a company. Background reading assisted in identifying requirements for each case by looking at the needs and critiquing what others have done. It also assisted in legitimising the author’s arguments.

After the “review of the field”, the Competence Profiling Methodology was developed. This included:

- Profiling questionnaire development: The design and development of the questionnaire was based on the method proposed by Wilson and McClean (1994) and supported by the Department of Education and Skills (DfES). Competence being the main concept to be measured, a working definition was required. Diverse literature sources discuss the issue of organisational competence resulting into different perspectives of competence

definition. A working definition was developed that incorporated the various perspectives identified.

- Website and database development: A Web-based system has been developed to make the collected competence information available for e-business use and formulating partnerships. To ensure a structured approach and consideration of all key aspects of system engineering, the development has been based on a well validated process proposed by Professor Sommerville (1995).

At this stage the Autocle@r project provided the author significant access to engineering SMEs, and allowed him to observe and interact with them. For example, the ability of engineering SMEs to meet a wide variety of customer requirements based on the key skills, machinery, and equipment available to them was one of the key observations first made during that period.

The developed methodology was then tested on eighty two engineering SMEs through application in both the Autocle@r and Autolean 3 programs. Experts' and users' feedback was taken into account and further improvements were made. Some of the key improvements are described in paragraph 5.3 on page 115. In addition, user assessments were made to capture the perceived usefulness of the methodology. These were performed with the assistance of Advantage West Midlands (AWM) and the Northern Defence Industries (NDI) Ltd (see paragraph 5.2 *Further implementation and testing*).

Further testing of the Competence Profiling Methodology to a different dataset was also made through its application to the MAS-WM. This enabled assessment of the



methodology within the advisory sector. Acquiring responses and feedback provided the author with the opportunity to further assess and develop its effectiveness (see paragraph 5.4 in page 128) and make safer judgements to its applicability to industry.

Finally, the reflecting and integrating stage mainly involved the writing of submissions as well as the dissemination and testing of the knowledge acquired through publications (see *Appendix 1*), presentations and demonstrations either at conferences or to project partners and users of the methodologies. These demonstrate how the research results relate to current thinking and how this fits into the knowledge field. This stage also involves some commercial outcomes reported as a direct result of the work undertaken. Opportunities for further research are also identified in publications, submissions, and in this Executive Summary (*7.1 Recommendations for further work*).

This Executive Summary is structured to reflect on the phases followed in this research. The following chapter starts by reviewing the key issues that inhibit e-business adoption by engineering SMEs and will proceed with the examinations of theories and practices of supplier identification and appraisal.

### 3. Engineering SMEs and E-Business

Although the benefits for adopting e-business are regarded as being significant by the UK government (DTI, 2004a; DTI, 2004b), UK engineering SME e-business adoption rates are quite low. Doing business on the Internet promises greater market penetration, increased customer response, more flexibility, lower costs, increased income, and the formation of new business avenues (DTI, 2003b; DTI, 2004b). However, less than 10% of UK manufacturing SMEs business comes through the web (MCS, 2002). As a result of the interactions the author had with engineering SMEs during the research, as well as through the examination and analysis of existing solutions for partner and supplier identification and appraisal, six key issues that hold back e-business adoption were identified:

1. Trust

Many representatives of the engineering companies visited during the ‘Autocle@r’ and ‘Autolean 3’ projects argued that they were not confident in dealing with suppliers on-line. Some of them were stating lack of familiarity with on-line working. Many others felt more confident with their existing traditional methods of dealing with suppliers. That is mainly working with suppliers that they already know and trust or have been introduced to by a trustworthy contact. Identifying and even more selecting suppliers on-line was beyond their imagination. “How would I ever trust somebody that I have found on the web and I haven’t seen, talked, or even been introduced to?” were among the usual questions that were posed. It became quickly apparent to the author that trust was the main obstacle for engineering SMEs. Proof of this belief came at a later stage by a European study (Perogianni, 2003) where it was clearly stated that trust is an issue posing a major barrier to e-business adoption



by SMEs. The report recognises that trust matters for all stages of purchasing, from finding partners to purchasing, settlement and payment.

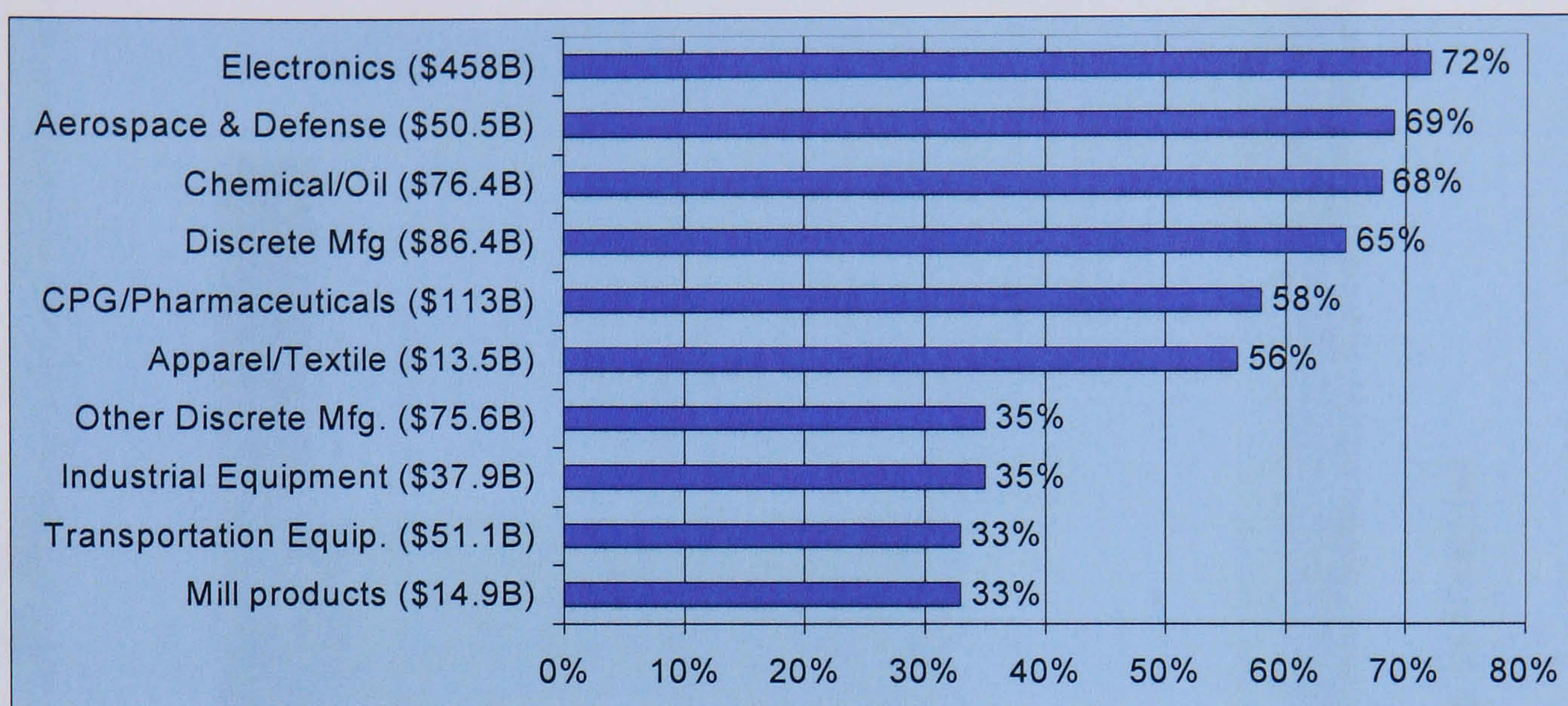
Handling trust effectively may be enough to convince the on-line technology “phobic” to learn and familiarise themselves with on-line working. This has worked in the consumer sector. E-Bay was rated as the most trustworthy company on-line (Greenspan, 2004), its rating system is key to this perception. Therefore, an approach that could assist SMEs to identify and select, confidently, competent suppliers on-line is needed.

## 2. Product Orientation

Existing e-commerce has a very strong “product” bias; it is based on transactions concerning products, whether they be insurance policies, vacuum cleaners or electric motors. This comment applies to not only the Business-to-Consumer (B2C) sector, but also the Business-to-Business (B2B) sector. The well developed catalogue capability in e-commerce supported by audio and visual enhancements of the web assists towards on-line trading of standard products. However, the products that many engineering SMEs offer are not standardised. They are often ‘one-off’ customised jobs and therefore cannot be represented by a standard list. For example, *Figure 2* shows predictions for the amount of trade in different sectors to be conducted on-line by 2004. It is clear the variation is mainly accounted for by the degree of standardisation in the industry. For example, electronic components are very standardised, whereas ‘Transportation’ and ‘Mill’ products are much more customised. GuiaNet (at [www.guianet.pt](http://www.guianet.pt)) is an example of an on-line directory that



focuses on classifying and characterising engineering ‘items’ bought and sold by companies. GuiaNet (*Figure 3*) does not focus on the full abilities of the potential partners.



**Figure 2 Predictions for the amount of trade to be conducted on-line by 2004**

### 3. Company Classification

A key assumption about engineering companies and e-commerce is that engineering companies should be classified by their existing products. Classifications such as the Standard Industrial Classification (SIC) and the United Nations Standard Products and Services Code (UNSPSC) attempt to facilitate exploitation of electronic commerce capabilities by focusing on classifying commodities. It was recognised in this work however that “products” are an output of the skills and capabilities of an engineering company. These skills and capabilities are far more generic than the products. That is, the same company using its existing skills and facilities could manufacture many variants and new products. The majority of representatives from the engineering companies visited claimed that they were able to serve a large



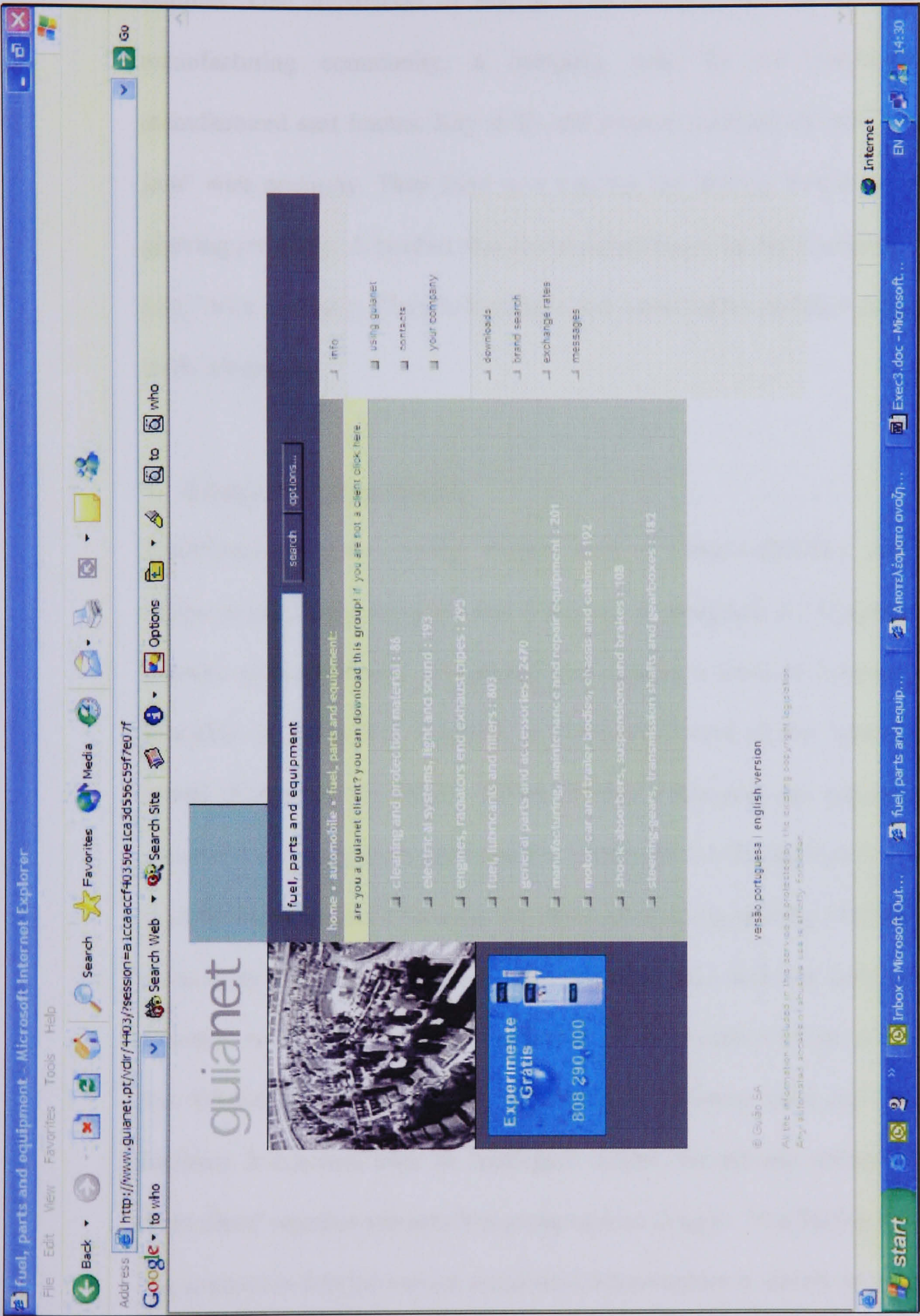


Figure 3 Example of search for partners in GuiaNet



variety of different sectors. Their cupboards were full of representative product samples. One illustration of this is a well-known case to the West Midlands manufacturing community, a company who for the automotive industry manufactured seat frames. Key skills and process included the ability to “bend and join” wire precisely. They have now become the leading World provider of body piercing jewellery. A product that also requires the skills and capability to “bend and join,” wire precisely. The profit margins are much higher and they judge the work as more interesting.

#### 4. E-business Uptake Models

Traditional e-business uptake models such as Cisco’s (2001b), Earl’s (2000) or Fingar et al (2000), presented and discussed in paragraph 3.1 (*Engineering SMEs - sources of competence*), are generic and require a level of resources not always available to SMEs. For example, in the second wave of the ‘three major waves’ model (Fingar et al., 2000), on-line product catalogues are suggested to handle electronic transactions. As discussed in paragraph 1.1 (*Background*), end products at a particular instance in time do not show all that engineering SMEs can really do. Even more importantly, just having a catalogue on a web site does not ensure that potential customers will be able to find it. An examination of the search enquiries at the WMCCM site shows that the product orientated ones arrive mainly from business directories, such as Applegate, whilst, the process orientated ones arrive from direct searches via search engines such as Google. This finding further supports the contention that the current e-business infrastructure is mainly product oriented.

### 5. Lack of Comparative Capability Information

The websites provided by many engineering SMEs are often outdated or lack any detailed, structured information covering their real abilities. The information available is usually not directly comparative. As a result of this, SME websites are often of limited use. Evidence of this is the significant “clicking off” of small businesses over the past few years. Connectivity has fallen by more than 17% in two years (DTI, 2003c) as SMEs perceive e-business to be of little value. Discussion with engineering SMEs at this time indicated their main use of the Web was to conduct research on competitors and potential customers. There are indications that website deployment has improved (DTI, 2004a). However, the sustainability of this improvement is not guaranteed as it may be a result of governmental efforts via funded schemes such as the ‘support to implement best practice’ to increase on-line business presence.

### 6. Service Fees and Charges

Although e-marketplaces, such as ‘Supply-On’ ([www.supplyon.com](http://www.supplyon.com)), may provide buyers with more detailed and structured information about potential suppliers, many SMEs are unable or unwilling to afford registration. For instance, the annual costs for an SME to register and use Supply-On can be up to 7,920 € (Supply-On, 2005). In addition, the aggregation of purchasing power offered by such buyer controlled e-marketplaces has raised many concerns among suppliers, who in particular fear that their margins would be squeezed.



In order for engineering SMEs and their business partners to gain the benefits of e-business, a solution that will reduce the barriers outlined above needs to be developed and this is the aim of the work presented in this document.

### 3.1 *Engineering SMEs - sources of competence*

For e-business the view that engineering SMEs could be seen as sources of competence, rather than products, was introduced at a very early stage in the research (Submission 1: *Moving Up the Food Chain*). This view differs from the traditional view to e-commerce, which is more focused on end products as discussed in the beginning of this chapter (points 2 and 3 in page 33). None of the major e-business adoption methodologies for SMEs really address this issue. There are three major e-business adoption methodologies (Bal and Blanco, 2002):

- The ‘three wave model’

Based on observations about what companies have previously experienced while taking-up the Internet, Fingar et al (2000) have defined three waves of e-business evolution:

- In the first wave, around 1992, companies developed a brochure type homepage to obtain web presence
- In the second, after 1996, companies added electronic transaction capability
- In the final wave, from 1999 onwards, companies started using the Internet to extend the business processes and operation in both sides of the supply chain

The model has been based on observations of what organisations such as Dell Computers and Amazon have experienced. This does not necessarily apply to the

needs of today's engineering SMEs. For example, Dell and Amazon are organisations where their on-line business model is mainly based on marketing standard products, such as books and electronic devices, and therefore on-line catalogues have a straightforward application. This does not apply to engineering SMEs which meet customer requirements/specifications based on what they are able to do and not on what their end products are.

- The 'evolving the e-business'

Earl (2000) describes a six-stage model for achieving and sustaining e-business:

1. External communication, where corporate information is made available to the public via a website
2. Internal communication, that is using the internet and www techniques to build internal communication channels, such as corporate intranet
3. E-Commerce, the ability to buy and sell products on-line
4. E-Business, where e-business is about re-engineering or redesigning business processes and replace legacy systems to incorporate e-business techniques
5. E-Enterprise, which is about decision-making becoming more informed by monitoring and analysing in real time information such as consumer behaviour and operational performance
6. Transformation, where the 'e' is dropped and companies are completely part of the new economy

The evolving e-business model was derived from Earl's (2000) evaluation of what large corporations and dotcom start-ups have done to evolve. Many engineering SMEs



lag behind those first movers as they do not have the resources and skills to follow such an evolution. In addition Earl's model examines the adoption of e-business at a strategic level and thus does not examine any detailed implementation issues such as the online publication of sensitive information.

- The Cisco Systems model

Cisco Systems (Cisco, 2001b) by having transformed their company and being one of the first movers in the Internet economy, justifies their understanding of needs of a business. Their model consists of five steps:

1. Connect – Email, business communication via the Internet
2. Grow- Website for posting product catalogues, promoting products, and gathering customer data
3. Trade – Introduction to e-commerce
4. Build - E-business, re-engineer business model to reflect on demands of the Internet economy
5. Evolve – Ecosystem, e-business tools facilitate links and interrelationships between business entities, supply networks and global business structures

Cisco's model is the first developed by practitioners. Adopted also by the Department of Trade and Industry (DTI, 2002b), it has been an adequate framework for an SME's Internet strategy development (Bal and Blanco, 2002). However, attempting to provide a general guidance of principles for all types of SMEs, it does not provide specific answers to engineering SME issues. Similar to the other models, it mainly refers to standard product providers with standard product catalogues rather than engineering

companies with many ‘one-off’ job requests and non-specific highly variable product types.

### 3.1.1 The need for competence

The increased complexity of automotive and aerospace systems makes it increasingly difficult for Original Equipment Manufacturers (OEMs) and 1<sup>st</sup> tier suppliers to develop complete final products by themselves. They increasingly rely on their suppliers to design and manufacture subsystems. In fact, it has been estimated that bought in subsystems constitute between 65 and 70 per cent of the value of a modern vehicle (MIRA, 1997; ILO, 2000). This requires OEMs and 1<sup>st</sup> tier suppliers to search for suppliers that can provide them with an appropriate level and breadth of competences. There is evidence that companies are using industry marketplaces such as Exostar to identify new alternative sources of supply. Exostar has over 12,000 registered suppliers providing its founders, Boeing, Lockheed Martin, Raytheon and Rolls-Royce with multiple supply options (Arminal, 2004).

SMEs need to demonstrate competence in response to customer needs. However, simply demonstrating competence in a narrow field may not be enough to convince customers. Suppliers such as Lear and Dana, two of the key global automotive suppliers (ILO, 2000), are increasingly focusing on providing whole systems, such as interior and braking systems, that they consider to be their core activities. These core activities are based on a combination of individual technologies and production skills, what Prahalad and Hamel (2000) describe as “core competences”. However, a core competence of an SME is only a fragment of that of a larger supplier. An appropriate breadth of competences is required in



order to allow SMEs to provide complete sub-systems and to undertake higher value projects, which as argued by Preiss et al (1996), provide better financial rewards.

SMEs need to show the appropriate skills, experience, knowledge of technology, and processes in order to develop and produce new enhanced products that will meet their customers' demands. The question is 'how do SMEs with limited resources cope with this?'

### 3.1.2 Options for increasing competence

Under similar pressures in the 1990's SMEs participated in a wave of consolidation. Daniels (1996) describes how in order to survive and sustain competitiveness automotive companies in general followed consolidation strategies, which allowed them to become larger, more diverse and international. As part of this strategy, three main types of action were taken (Daniels, 1996; Bursa et al., 1997):

1. Internal growth
2. Mergers or takeovers
3. Collaborations

The first requires a high level of investment, which SMEs often cannot afford. For mergers and takeovers SMEs need to sacrifice their independence which is often a problem with the family ownership structure integral to many engineering SMEs. This can also have a negative impact on the flexibility of an enterprise since it is bounded by the managerial bureaucracy of a larger enterprise (Bhaskar and Jamaluddin, 1993; Lawler,

1997). Collaboration could allow the aggregation of competences without sacrificing the flexibility of the small enterprise.

With the emergence of e-business technologies, collaboration is now an even more attractive proposition. Virtual organisations can be formed that “represent a temporary alliance of diverse organisations that form collaborative network, sharing knowledge, skills, and resources towards provision of value-added products and services and that resort to a computer network and associated tools to support their cooperation” (Afsarmanesh, 2005: p9). Tools such as virtual teaming kits are now available which are claimed to be low-cost and easy to use (DTI, 2004b). These tools provide the mechanisms for low cost collaboration, allowing SMEs to work together closely without losing their identity. An example of such a tool is Microsoft NetMeeting which enables users to chat on-line via text, voice or even video conversation in real time as well as share files and use common workspaces. A NetMeeting based collaboration system was devised and tested with engineering SMEs by the Warwick Manufacturing Group within the Autocle@r project. Many new providers such as Webex, Critix, and NicheGnat offer such facilities and competition is increasingly driving down costs.

The increased demand for modular design and the resulting need for an appropriate level and breadth of competence have garnered increasing recognition within the industrial community. Business analysts such as PriceWaterhouseCoopers (2002b) echo the necessity for suppliers to configure their assets around systems and platforms rather than individual components and move up the value chain.



“By pooling their resources in creative venture, suppliers can leverage their ‘niche’ expertise to deliver modular or highly engineered systems in which the individual parts have greater proprietary value because each has been tailored to a specific application” (PriceWaterhouseCoopers, 2002b: p9).

In their analysis of the UK economy, Porter & Ketels (2003) endorse collaboration through the development of clusters. They view the ‘cluster’ concept as a crucial element in enhancing competitiveness.

“A more conducive environment for productivity growth and innovation through the collective action of companies and other institutions” could be achieved (Porter and Ketels, 2003: p23).

Similar emphasis has been placed by the European Commission (2002a), which promotes the clustering concept through its ‘cluster policies’ to strengthen inter-firm collaboration and business networking.

### *3.2 Updated Research on E-Business and Partnership selection for SMEs*

Tools for identifying, appraising and selecting engineering SMEs within an e-business environment are increasingly available. This suggests that there is a real need and also acceptance of the concept by the business community. In the following paragraphs an update of current practices and theories that support the process of identification, appraisal and selection of engineering SMEs is provided.

### 3.2.1 Partner/supplier identification

An increasing number of business/trade directories have emerged providing the main means for on-line partner/supplier identification. Examples of them can be found in regional portals, such as:

- the '*n-e-life*' (at [www.n-e-life.com/forbusiness/miniwebsites.php](http://www.n-e-life.com/forbusiness/miniwebsites.php)) in the North East region of the UK
- 'China Sourcing' (at [www.china-sourcing.com](http://www.china-sourcing.com)), which promotes the products offered by companies across China
- the 'Asia Trade Hub' (at [www.asiatradehub.com](http://www.asiatradehub.com)), which lists companies across all major Asian counties
- the 'Alibaba International' (at [www.alibaba.com](http://www.alibaba.com)) manufacturing directory primarily serving SMEs, with one million registered users from over 200 countries

What is common is the limited information provided about listed companies. For instance *n-e-life* provides only contact details for its listed companies. In addition, companies are usually classified according to their end products, as for example in China Sourcing and Alibaba, an approach that is insufficient for innovative, higher value added work. As argued by Meyer and Utterback (1993), it is those skills and assets that exist in a firm that result in the development of new successful products delivered in chosen markets. Products are only instances of what an engineering company can do and does not show all it does.



First Index (at [www.firstindex.co.uk](http://www.firstindex.co.uk)) is an interesting example of an on-line marketplace for custom-manufactured parts whose directory embraces engineering SMEs from all UK regions including the West Midlands. First Index also has operations in Germany, USA and Sweden. Approximately 10,000 purchasing departments and professionals use the First Index system from all sizes of company including highly respected global manufacturers such as GKN and DENSO. Its services have key benefits as well as some weaknesses. Key benefits include:

- First Index provides the ability for engineering companies to present a profile of their activities. An example of such a profile is shown in *Figure 4*. A list of manufacturing process (*Figure 5*), is also available. This enables the user to have a quick snapshot and make an initial assessment of the capabilities a supplier has to offer.
- To generate a company's profile in First Index, an expert interviews key representatives of the company. This enables selection of appropriate information and consistency in its presentation and valuation.
- Information collected is stored in a database and is searchable via an on-line facility (*Figure 6*) making it easily accessible at any time. Keyword or structured searches for specific manufacturing processes within specified locations and with indicated approvals can be made.

However, there are also key weaknesses:



## RAYBURN PLASTICS LTD

Established in 1959 Rayburn Plastics has a reputation for engineering excellence. Equipped with the very latest CAD/CAM systems and CNC machine tools for turning, milling, routing and profiling, and specialised equipment for bending, vacuuming and polishing. Rayburn's skilled engineers produce an unusually varied range of products for a wide and growing customer base in both plastics and metals. All parts are manufactured in accordance with BS EN ISO 9002. Recognition by "Investors in People" further establishes Rayburn's dedication and commitment to quality.

COMPANY DETAILS

Whitehouse Street  
Walsall  
West Midlands  
WS2 8HR Map  
United Kingdom  
sales@rayburn.co.uk  
http://www.rayburn.co.uk/

credit rating from D&B

TELEPHONE

01922 625572

FACSIMILE

01922 723333

CONTACT

Mr Ian  
Micklewright

EMPLOYEES

51 - 100

TURNOVER

£3,000,000

AREAS SERVED

National and International

APPROVALS & AFFILIATIONS

BS EN ISO 9001: 2000  
Investors in People

A SELECTION OF CLIENTS

Alstom Group  
British Aerospace  
Xerox Ltd  
Britax aircraft cabin  
interiors/seating  
Royal Shakespeare Co

PLANT LIST (SUMMARY)

1 x CNC Quick Turn machining centre  
2 x CNC lathes  
3 x centre lathes  
3 x capstans up to 1" dia  
9 x CNC multi-tool machining centres  
4 x CNC milling machines  
3 x semi-automatic milling machines  
8 x milling machines  
1 x CNC router 1650 x 1250 x 350  
1 x CNC router 920 x 620 x 150  
  
1 x CNC engraver 520 x 320 x 30  
1 x CNC beam saw 3000  
6 station turret drills  
18" throat band saws  
2000 x 80 panel saws  
Power guillotine 50" x 2mm  
Vacuum forming machines 32" x 24" x 4"  
Thermal bending machines 2000mm  
Acrylic diamond edge polisher  
Sonic welders  
High speed tapping spindle  
Further equipment:  
Flame polishing, handpresses and spraying facilities

SPECIALIST AREAS

Tooling for the electronics industry  
Machining of high temperature and high performance plastics  
precision machining of alloys for the aerospace industry

Figure 4 Example of detailed profile in First Index

Category listing:

MACHINING, boring, horizontal  
MACHINING, boring, vertical  
MACHINING, complete manufacturing  
MACHINING, design, development & prototyping  
MACHINING, drilling  
MACHINING, drilling, deep hole  
MACHINING, engraving  
MACHINING, machining, cnc centres  
MACHINING, machining, cnc centres  
MACHINING, machining, conventional  
MACHINING, machining, high precision  
MACHINING, machining, multi-axis  
MACHINING, machining, plastics  
MACHINING, machining, tungsten carbide  
MACHINING, milling, cnc  
MACHINING, milling, conventional  
MACHINING, slotting  
MACHINING, spark erosion  
MACHINING, tapping  
MACHINING, thread cutting  
MACHINING, turning auto  
MACHINING, turning cnc  
MACHINING, turning, conventional  
TOOL MAKING, jigs & fixtures  
TOOL MAKING, pattern & model making  
TOOL MAKING, tool cutting  
PLASTIC & RUBBER, assembly  
PLASTIC & RUBBER, design, development & prototyping  
PLASTIC & RUBBER, gaskets  
PLASTIC & RUBBER, grp moulding  
PLASTIC & RUBBER, injection moulding  
PLASTIC & RUBBER, plastic extrusions  
PLASTIC & RUBBER, plastic fabrication  
PLASTIC & RUBBER, thermoforming  
PLASTIC & RUBBER, thermosetting  
PLASTIC & RUBBER, vacuum forming  
ELECTRONIC/ELECTRICAL, electromechanical assembly  
ELECTRONIC/ELECTRICAL, testing & repair  
FINISHING, anodising, colour  
FINISHING, anodising, hard  
FINISHING, polishing  
FINISHING, silk screening  
PRE TREATMENT, blasting, bead  
PRE TREATMENT, blasting, sand  
PRE TREATMENT, deburring  
PRE TREATMENT, degreasing & cleaning  
SERVICE & REPAIR, ndt

Figure 5 Example of a company's list of manufacturing processes in First Index

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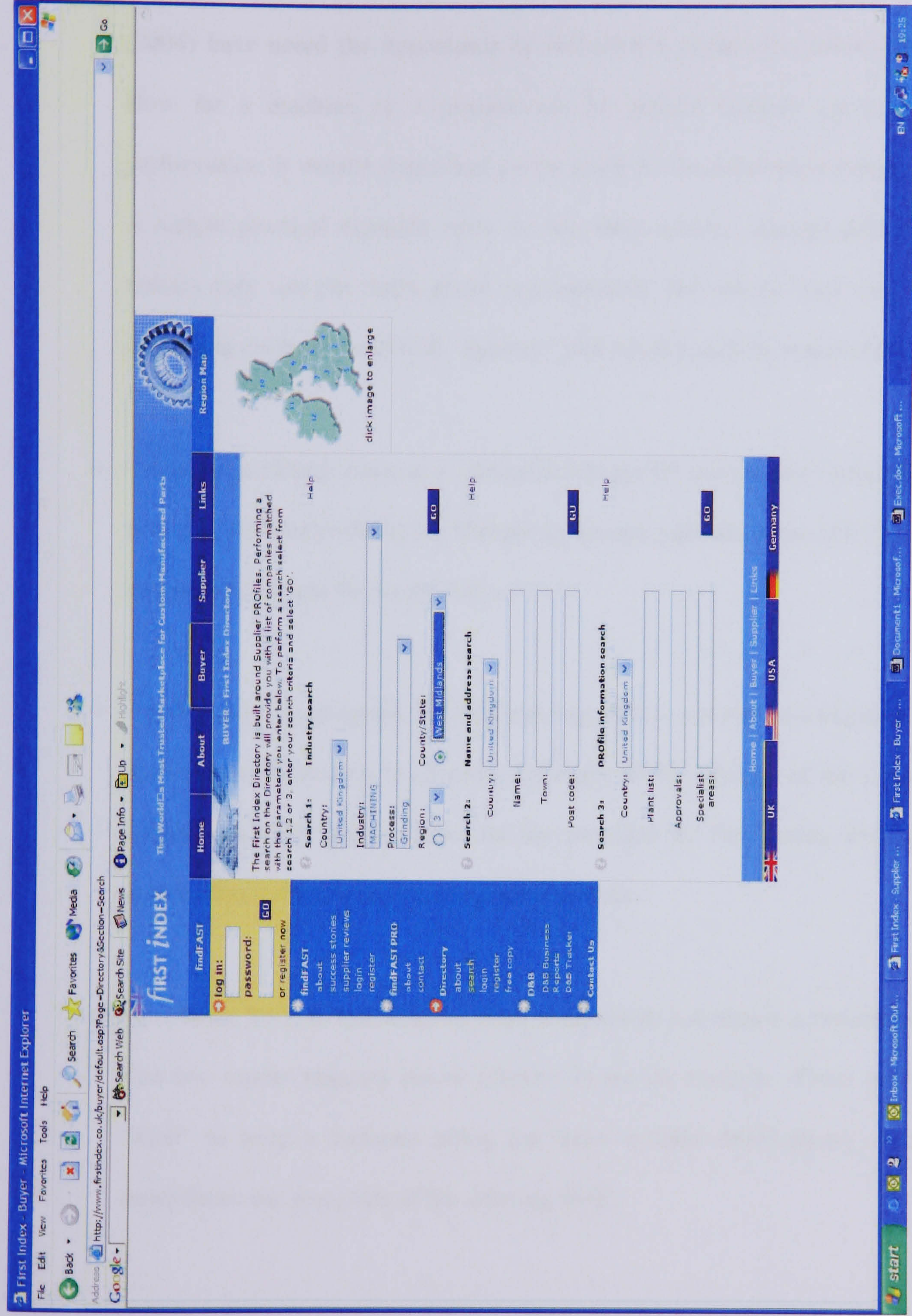


Figure 6 Example of search in the First Index on-line directory



- The abilities of the employed staff are not included within the First Index profiles. Authors such as Kandel et al (1991), Miyazaki (1995), Ostwald (1997), and Slack et al (2004) have noted the importance of individual's experience, know-how, and skill. How far a machine or a process can be pushed towards its highest level of performance, is usually dependent on the skills of the individuals driving the process. A simple practical example from the jewellery sector; although different jewellery makers may use the same pliers and mandrels, the results may vary significantly depending on the level of skill "mastery" individual jewellery makers have.
- Company profiling comes at a substantial charge for companies. Companies that wish to have a detailed profiling are charged an annual registration fee of £1500, this is seen as a major problem for many SMEs.
- As discussed in paragraph 3.1 (Engineering SMEs - sources of competence), enabling inter-firm collaboration is essential for many SMEs because of the limited range of competences they provide. The facility provided by First Index does not facilitate establishing collaborations among manufacturers.
- First Index tends to specialise in small jobs that do not require a breadth of capability. The two tender requests below (*Figure 7*) are an example. These jobs are OK as "food" to keep a business going but there is little development of the markets, capabilities and prospects of the winning SME.



Tender 1	
Originator:	First Index
Contact Name:	Sharon Tuersley
Contact Phone:	024 76524805
Respond By:	22/07/2005
Summary:	***URGENT QUOTATIONS REQUIRED*** This client is urgently requiring quotations for a supplier to carry out bright chrome plating of mild steel tubular components. These items will be required for a display stand/frame assembly.
Size:	Various sizes: 35mm x 20mm 1.5mm - 1200mm length 35mm x 20mm 1.5mm - 760mm length 30mm x 15mm x 1.5mm - 380mm length 30mm x 30 mm x 1.5mm - 1200mm length 30mm, x 30mm x 1.5mm - 760mm FOR THE SQUARE TUBE ASSEMBLY ITEM, PLEASE REFER TO SKETCH. FOR THE OTHER ITEMS, PLEASE REFER TO THE QUANTITY & SPEC SHEET.
Tender 2	
Originator:	First Index
Contact Name:	Sharon Tuersley
Contact Phone:	024 76524805
Respond By:	17/08/2005
Summary:	Bending and Guillotining required for Handrails. RE-REPORTED WITH ADDITONAL INFORMATION
Size:	3 metre lengths, varies thicknesses generally 1.5mm
Materials:	Stainless steel
Main Category:	SHEET METAL
Sub Category:	General Sheet Metal
Number of Employees	31 - 50
Indication:	
Activity Indication:	Mnfr Crash Barriers

Figure 7 Examples of First Index tenders

MfgQuote ([www.mfgquote.com](http://www.mfgquote.com)) is another example of a specialised manufacturing e-marketplace that focuses on engineering SMEs. MfgQuote is North America based and focused. With approximately 17,000 buyers using this system including OEMs such as BMW and Boeing Satellite Systems, it appears to be a well accepted solution by the US and Canadian manufacturing community.

MfgQuote’s business directory services are not much different than those of First Index. However, MfgQuote is interesting as an example of a service that considers the issue of organisational “compatibility” within inter-firm relationships. Authors such as Camarinha-Matos and Afsarmanesh (2003) have raised the issue of how to identify compatibility when selecting partners so that companies are well-matched and able to cooperate harmoniously. As suggested by Samadhi and Hoang (1998), value systems, corporate culture and manufacturing systems are examples of compatibility aspects that need to be considered to achieve a viable match of companies. MfgQuote takes into consideration



systems and cultural compatibility among companies by providing users with the ability to select (*Figure 8*) the preferred type of CAD systems and the type of “minority” the owners of the companies belong to. It should be noted, however, that the ethnic and gender minorities suggested by MfgQuote may be against the UK and European Community legislation. For instance, the UK ‘Race Relations Act’ makes it unlawful to discriminate against anyone on grounds of ethnic origin and it imposes general duties on many public authorities to promote racial equality (HMSO, 2000). The option of “minority” suggested by MfgQuote appears to be against this Act. However at the same time, organisations are increasingly being asked to monitor the ethnic origin of bidders, and there is increasing pressure to ensure a relatively even allocation of tenders according with ethnic distribution. Towards this direction is the UK Treasury which demands that such distributional issues are considered in proposals (HMTreasury, 2003).

MfgQuote’s company profiles are similar to First Index (*Figure 9*). Although ‘specialist areas’ and ‘key clients’ sections are not available, the system allows the user to create a preferred list of suppliers. In addition, registered companies are rated based on feedback received from customers on awarded requests for quotes (RFQs) (*Figure 8*). Despite this, a key drawback of the service is once again its high annual fees. In particular, suppliers are charged \$4,000 per year, a considerable amount for many small companies. This high charge is a result of MfgQuote’s income structure, as suppliers are considered as the main streams of income. Their revenue model is analogous to suppliers paying to be in a directory or exhibit in a trade show to gain exposure to buyers. The system is provided to buyers free of charge.



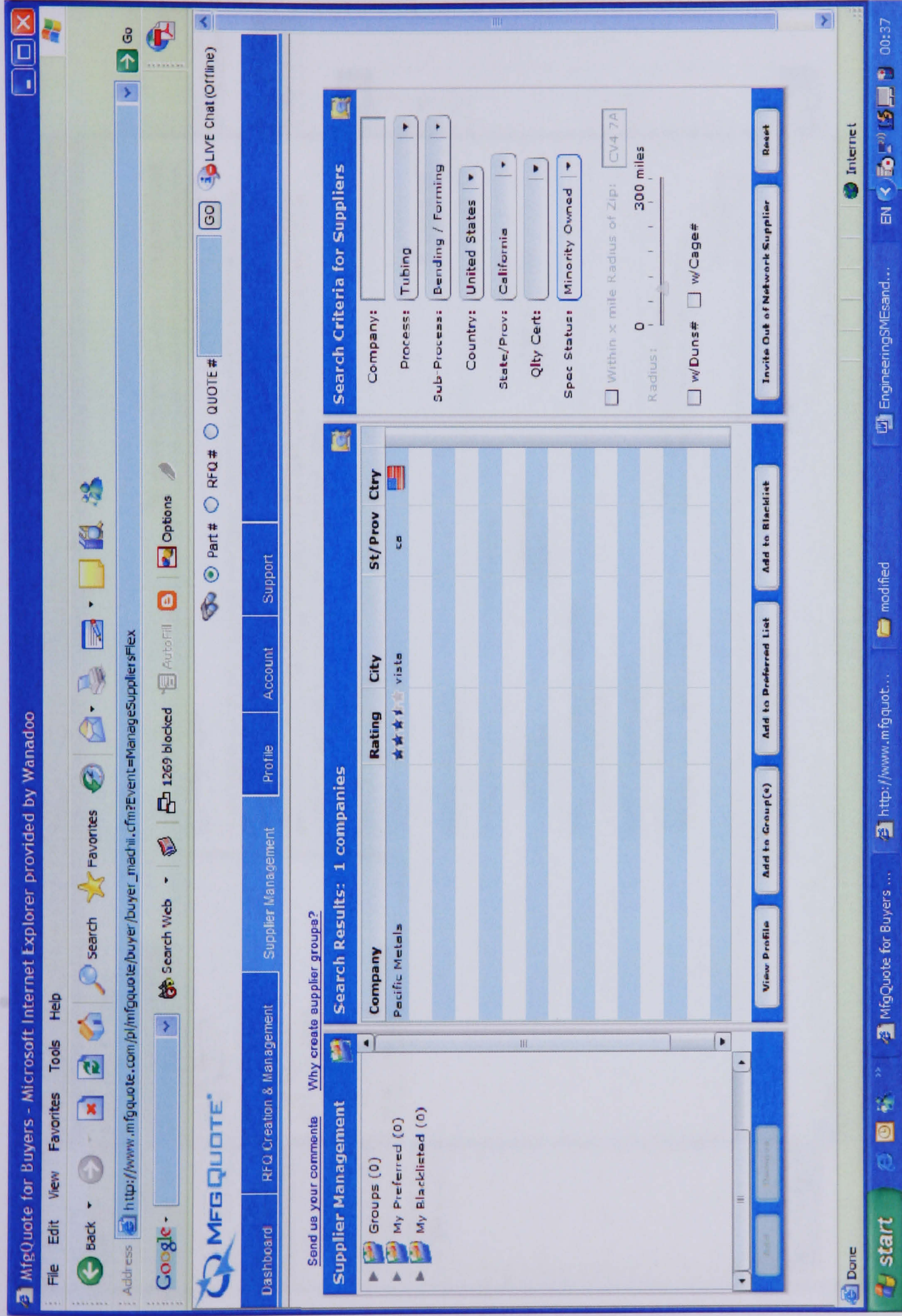


Figure 8 Example of search in the MfgQuote on-line directory



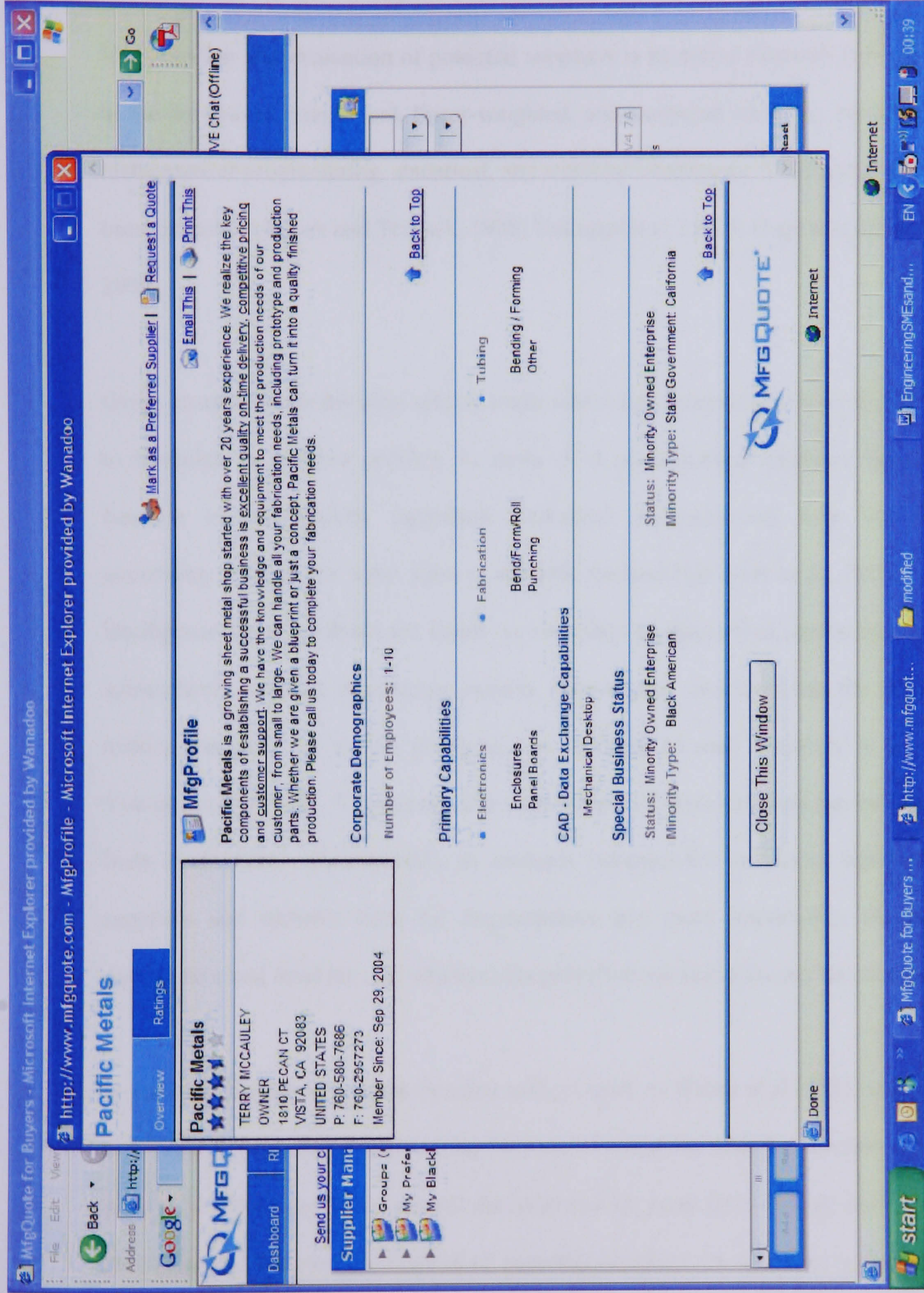


Figure 9 Example of a manufacturers profile in MfgQuote



### 3.2.2 Partner/supplier appraisal and selection

Identification and evaluation of potential suppliers is an active research field. In addition to the cost-based, categorical, linear-weighted, and analytical hierarchy process methods, mathematical programming, statistical, and artificial intelligence based methods have also been proposed (Ronen and Trietsch, 1988; Vokurka et al., 1996; Degraeve and Roodhooft, 2000).

Given an appropriate decision setting, mathematical programming allows decision makers to formulate a decision problem in terms of a mathematical objective function. This function is subsequently optimised. Statistical methods deal with the stochastic uncertainty such as for when there is unstable demand (De Boer et al., 2001). Artificial intelligence based methods are based on computer programs that can be trained by and subsequently emulate purchasing experts. Non-experts can then use the program for making decisions on similar problems. An example of such a system is provided by Vokurka et al (1996). A summary of a wide variety of these methods can be found in De Boer et al (2001). This diversity of methods indicates the increasing significance that suppliers and partners have for organisations and more importantly the increasing significance and need for well structured supplier/partner selection and decision processes.

In contrast with reviews made by other authors such as Weber et al (1991) and Degraeve et al (2000) which focus only on the final choice phase in supplier selection process, De Boer et al (2001) recognise several decision-making steps prior to that, such as problem definition and the pre-qualification of potential suppliers. In addition, in their proposed framework, the diversity of purchasing situations is recognised by making a distinction



between first time buyers, modified rebuys, and straight rebuys of routine or strategic items (*Table 3*). From their analysis of the methods reported it is concluded that the greatest amount of attention is paid to the final choice phase. The rest of the phases including the pre-qualification of potential suppliers receive far less attention from researchers in purchasing and supply, especially when a “new task” is involved. The literature is mainly focused on selecting suppliers for the purchase of standardised products in a manufacturing environment rather than on services. These two conclusions confirm what this research claims to be the main gap in existing studies and practices, posing a substantial barrier for engineering SMEs to be reliably identified, compared, and selected in an e-business environment. That is to say, the lack of a structured methodology that supports the initial stage of supplier discovery and promotes the “services” that engineering SMEs can offer based on their competences.

Concentrating on the partnership formulation literature, an area that is attracting increasing research interest is that of partner selection within an SME based virtual organisation setting. In suggesting, creating and sharing a Computer Integrated Manufacturing (CIM) system to SMEs, Samadhi and Hoang (1998) proposed a method for assisting companies in selecting suitable partners. This operates on the basis that one or several manufacturers play the role of the initiator(s) in leading the collaboration.

The proposed process of partner selection by Samadhi and Hoang (1998) consists of three broad phases (*Figure 10*). In the first phase all non-quantifiable and strategic factors, such as corporate culture, are considered. In the second phase factors that are related to the

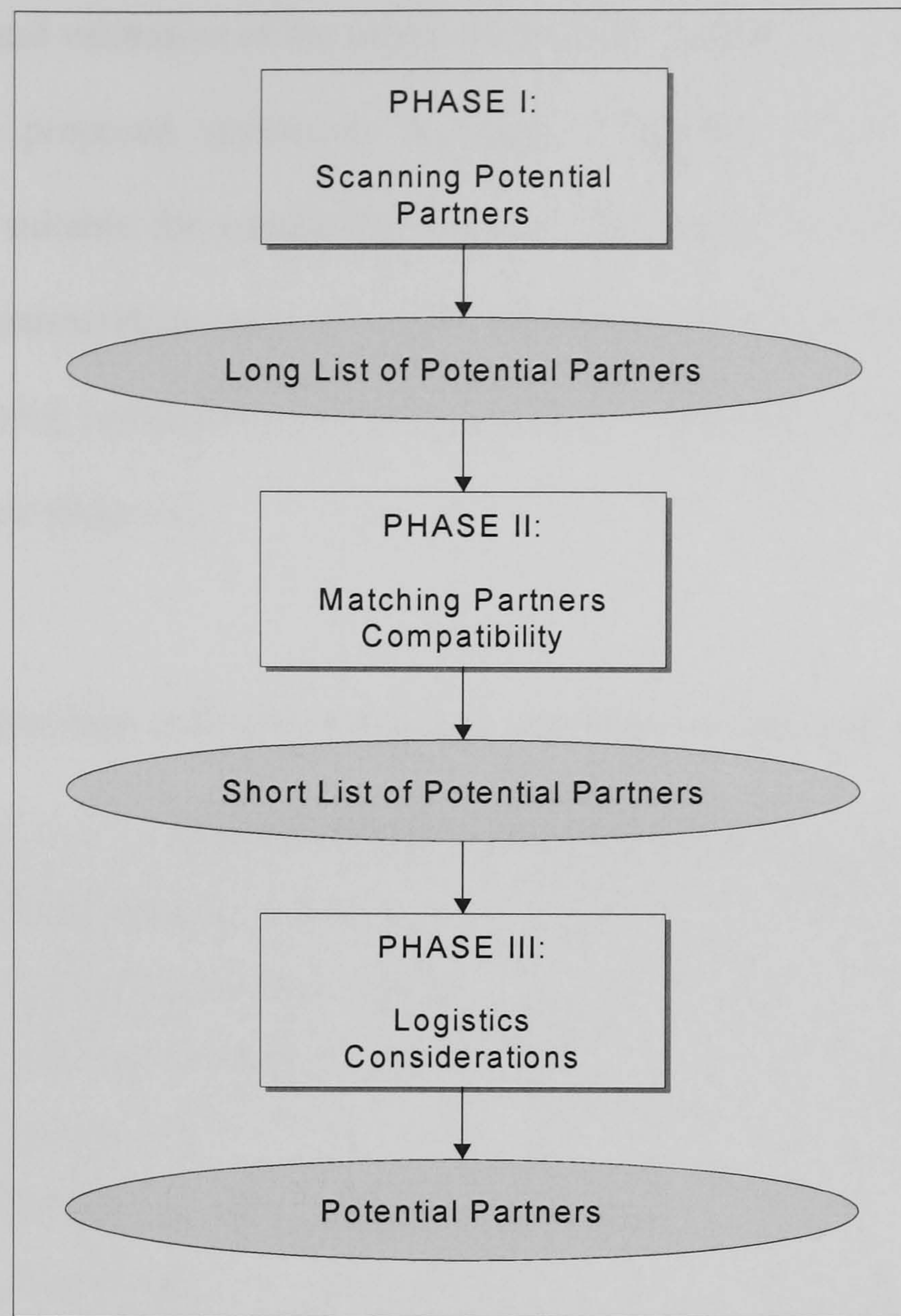


Table 3 The supplier selection framework

(Source: A review of methods supporting supplier selection (De Boer et al., 2001))

	New Task	Modified Rebuy (leverage items)	Straight Rebuy (routine items)	Straight Rebuy (strategic/bottleneck) How to deal with the supplier?
Problem definition	Use a supplier or not? Varying importance One-off decision	Use more, fewer or other suppliers? Moderate/high importance Repeating decision	Replacing the current supplier? Low/moderate importance Repeating decision	High importance Repeating evaluation
Formulation of criteria	No historical data on suppliers available No previously used criteria available Varying importance	Historical data on suppliers available Previously used criteria available	Historical data on suppliers available Previously used criteria available	Historical data on suppliers available, yet very few actual selections Previously used criteria available
Qualification	Small initial set of suppliers Sorting rather than ranking No historical records available	Large set of initial suppliers Sorting as well as ranking Historical data available	Large set of initial suppliers Sorting rather than ranking Historical data available	Very small set of suppliers Sorting rather than ranking Historical data available
Choice	Small initial set of suppliers Ranking rather than sorting Many criteria Much interaction No historical records available	Small to moderate set of initial suppliers Ranking rather than sorting Also: how to allocate volume? Fewer criteria Less interaction Historical data available Model used again	Small to moderate set of initial suppliers Ranking rather than sorting Fewer criteria Less interaction Historical data available Model used again Single sourcing rather than multiple sourcing	Very small set of suppliers (often only one) Historical data available Evaluation rather selection Sole sourcing





**Figure 10 Process of partners selection as proposed by Samadhi and Hoang (1998)**

attributes of the manufacturing systems are taken into consideration such as those presented in *Table 4*. In the last phase logistical factors are considered. According to Samadhi and Hoang (1998), if the geographical location of the initiator(s) and the potential partners is not within reasonable distance, the effectiveness of the partnership may be compromised due to the high costs of transportation and handling.

The work presented by Samadhi and Hoang (1998) introduces factors such as culture and manufacturing infrastructure, which as discussed in submissions 2 and 3, are important in the process of partnership formulation. However, there is no evidence of real-life



implementation and validation of the proposed method. In addition, a shared CIM system such as the one proposed appears to be highly inflexible. As the authors state, the approach is not suitable for companies that use very special or unique manufacturing processes. Such partnerships lose one of the significant benefits of collaboration. This is collaboration among companies with complementary competences, which this research places particular emphasis on.

**Table 4 Manufacturing system attributes as captured by Samadhi and Hoang (1998)**

**Manufacturing System Attributes**

1. Order-winning criteria
2. Type of demand generation
3. Nature of product
4. Product mix
5. Design attributes
6. Process type
7. Level of production planning and control computerisation
8. Level of manufacturing automation

The importance of competences in partnership formulation is verified by a survey conducted by Hitt et al (2000). Although the focus of the study is on identifying differences in partner selection priorities between emerging and developed market enterprises, the conclusions made for the developed market-based enterprises are similar to this research. They surveyed eighty-nine large companies, based in North America and Europe. The results clearly indicated that ‘unique competences’ is their top priority factor when seeking a partner (*Table 5*).



**Table 5 Priorities in selecting partners for developed market enterprises**

(Source: Partner Selection in Emerging and Developed Market Contexts: Resource and Organisational Learning Perspectives (Hitt et al., 2000))

Priority	Criteria
1	Unique competences
2	Market knowledge/access
3	Previous alliance experience
4	Cost of alternatives
5	Industry attractiveness
6	Special skills to learn from partner

This growing need for collaboration between companies with complementary competences is also cited by Lau and Wong (2001). Recognising that the process of searching and identifying partners is the most crucial as well as time-consuming part in the formation of a virtual organisation, Lau and Wong (2001) propose a partner selection and information infrastructure for SME manufacturers. The proposed partner selection scheme consists of five virtual agents, which undertake the following tasks:

- Coordinating agent; inputs the request of the partners and sends them out to other partners.
- Communication agent; receives and sends message packets and ensures quick and safe communication among partners based on Hyper Text Transfer Protocol.
- Information agent; deals with decision-making based on knowledge and information from other agents.
- Cyber search agent; assists in the search and collection of information on web-sites. It finds, ranks, and analyses the information that partners want. It can search the Internet using commercial search engines such as Infoseek and Yahoo.



- Reporting agent; collects and sends information to partners about the operational situation and performance of the virtual organisations in which they participate.

The scheme is integrated into a ‘Virtual Enterprise Network’ (VEN) infrastructure that incorporates the task of production scheduling and allocation of jobs to different plants based on the capabilities of each plant. VEN assists the exchange of information among various enterprises, co-ordinates and updates the local CAD files, and generates Numerical Control (NC) programs.

Although the work described by Lau and Wong (2001) complies with the conceptual base of this EngD, it appears to have some significant differences on the application level. Lau’s and Wong’s (2001) idea of forming virtual organisations dynamically by matching the skills and competences of engineering SMEs based on customer requirements, coincides with the goal of this EngD. However, the Lau and Wong infrastructure does not propose a structured approach to capturing and presenting engineering SME competences. This is an essential requirement for the formation of virtual organisations that has been also acknowledged by Camarinha-Matos and Afsarmanesh (2003) as a challenging issue that requires further research. In addition, apart from communication purposes, it appears to use the Internet for making searches through general purpose search engines such as Yahoo. In a later work (Lau et al., 2001) it seems that considerable effort has been applied to the after-selection assessment of partners. The performance of partners is continually monitored and new selections are made based on the collected performance data. The key criteria used are delivery lead-time, price level, and quality. A prototype web facility has been developed to enable users to view performance assessments. However, a weakness is the assumption that companies have in place mechanisms for collecting such data and



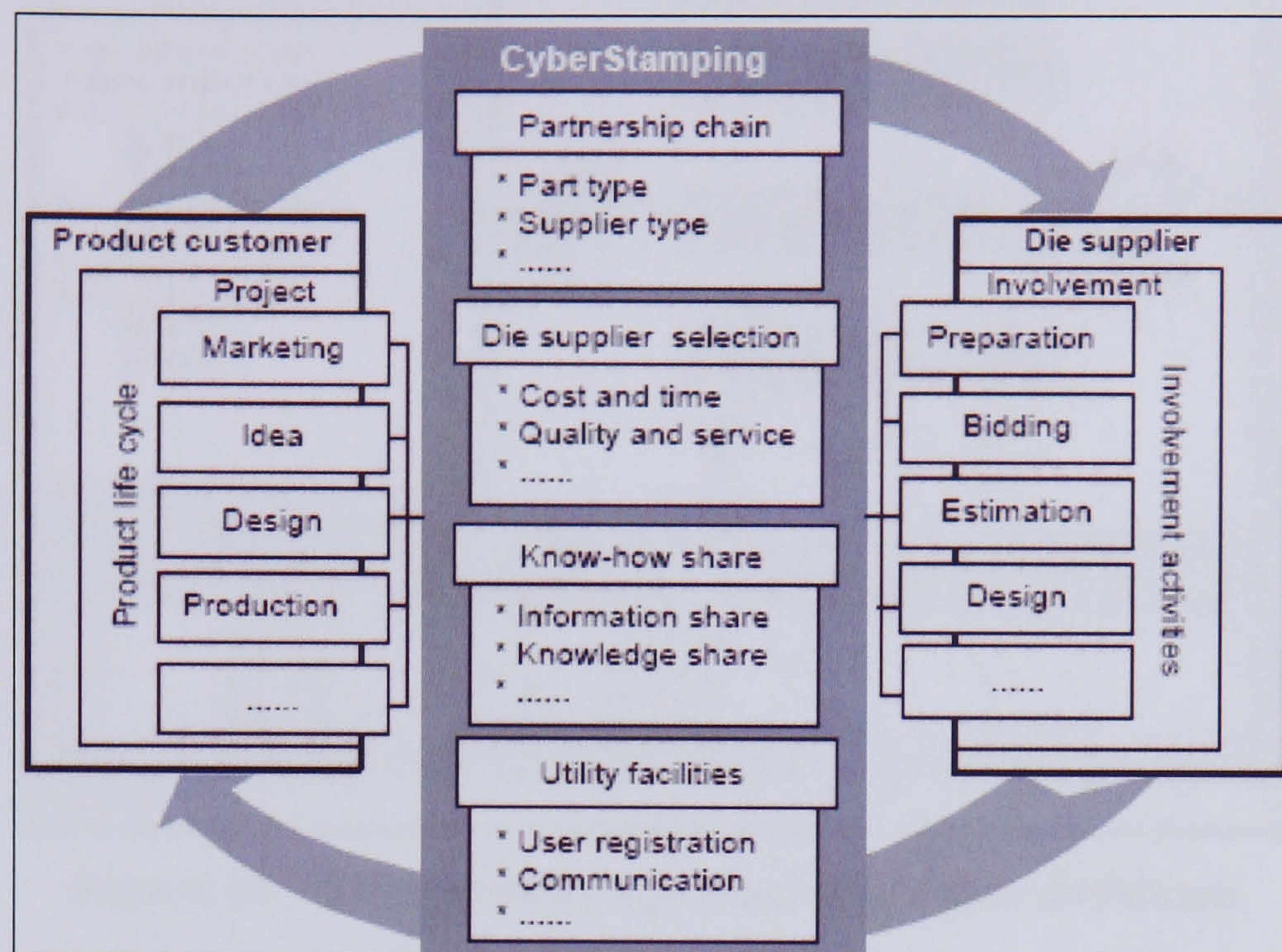
storing it in a structured form. Only a few of the SMEs that the author has visited had some form of such a data collection mechanism. In fact the original thoughts for the research were formulated when visiting a GKN facility, asking the question about supplier selection, and finding that the supplied supplier evaluation data was incomplete, outdated and obviously not maintained. The work presented by Lau and Wong appears also to aspire to achieve high levels of automation and integration within many processes from partner selection to the generation of NC programs. This is likely to generate a bureaucratic, inflexible system and the level of initial commitment required would be beyond most SMEs. In addition, the economic sustainability of the proposed application over time is an aspect that is not clearly examined and therefore its viability may again be in question.

A Web-based supplier selection tool is also described by Tang et al (2004). This is part of a Web-based environment for co-operative stamping product development, ‘CyberStamping’ (*Figure 11*). Based on the principles of early supplier involvement, CyberStamping acts as a supporting environment and interface between customer and die supplier. It provides the following fundamental functions:

- *Partnership chain definition.* The relationship between the customer and various die suppliers is defined.
- *Die supplier selection.* The supplier selection module assists the customer to evaluate and select appropriate die suppliers.
- *Knowledge share.* Knowledge share facilitates know-how and data exchange between product designer and die supplier.



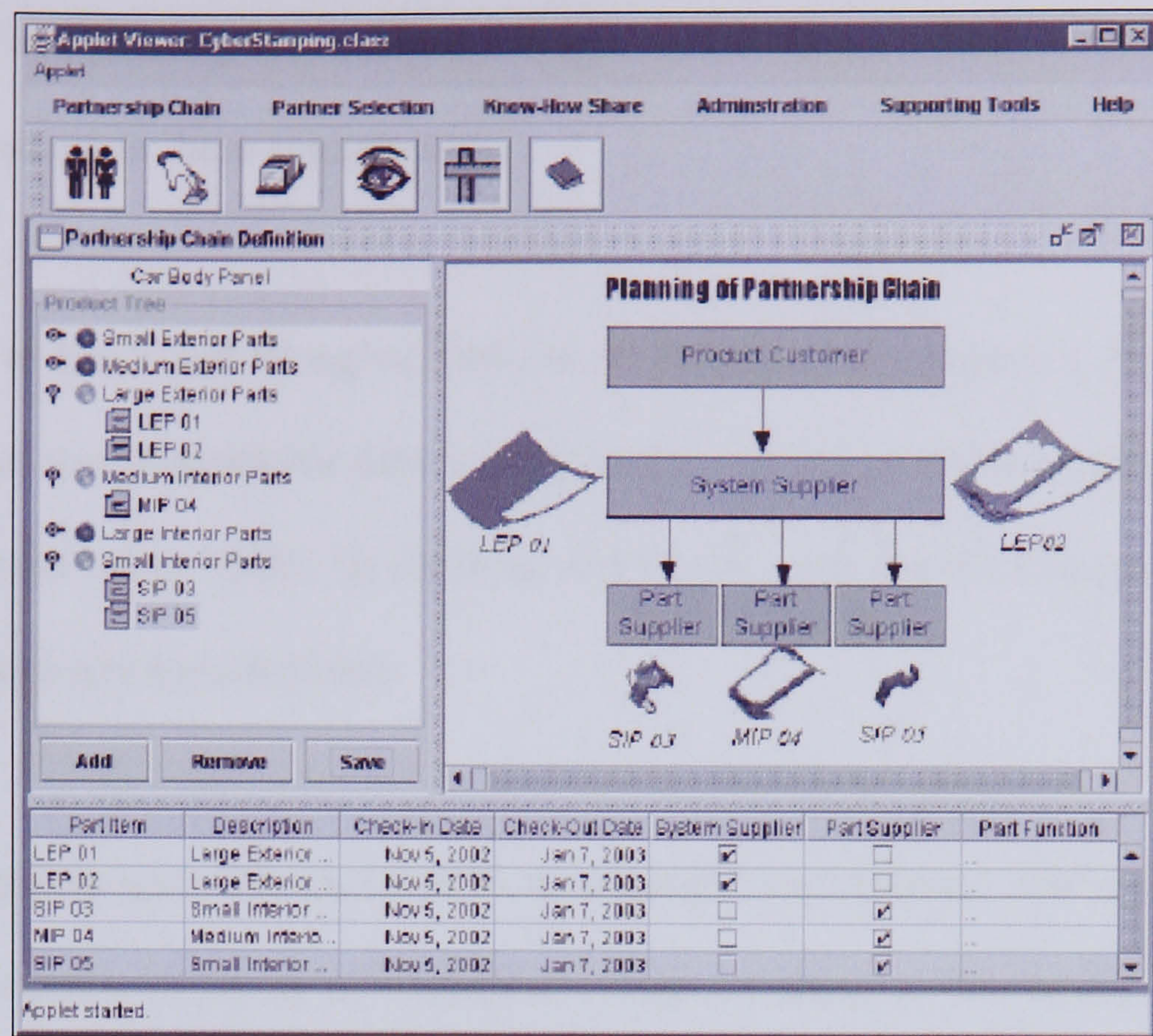
- *Utility facilities.* Utility facilities provide supporting functions, such as user login management, on-line discussion, and Website administration.



**Figure 11 Framework of CyberStamping as introduced by Tang et al (2004)**

Having initially defined the structure of the partnership chain by using a product tree (Figure 12), the customer invites tooling bids. Die supplier candidates may start the process of submitting bids. Once the customer receives all the bids, the evaluation and selection of partners begins. The evaluation of die supplies is performed using the formulation of an objective function, which considers six attributes; delivery ability, lead time, cost, service, quality, and flexibility. The Analytical Hierarchy Process (AHP) method is suggested by the authors for the allocation of weights associated with these attributes. Different combination sequences of die suppliers are evaluated based on the objective function and then the best choice is selected.





**Figure 12 The interface of partnership chain definition**

(Source: CyberStamping: a Web-Based Environment for Cooperative and Integrated Stamping Product Development (Tang et al., 2004))

The supplier selection module within ‘CyberStamping’ has aims in common with this research. It is a web based tool that focuses on the identification of a set of suppliers. However, there are some key practical weaknesses:

- CyberStamping focuses only on one competence within one industrial sector. That is the ‘metal stamping tool and die’ within the automobile sector. Conversely, a cross engineering view would enable the development of a product through the matching of a number of complementary competences which may not be directly relevant to the sector the product belongs to. Examples of such products or systems from the rail and defence industry are provided in section 5.2 *Further implementation and testing*. In these examples more than one competence in areas such as press-work, plastic injection



moulding and painting are required. Companies that may not be “classified” as industry specific can cover these competences.

- Similarly to Lau’s and Wong’s (2001) work, selection of suppliers is dependant on the assumption that quantitative data such as lead times are available to companies, which is not true for many SMEs. In addition, soft issues, essential for effective partnerships, are not taken into consideration.
- CyberStamping has not been tested in an industrial environment. The supplier selection module appears to be at a conceptual stage as there is no facility available for automating the process of evaluating and identifying the optimum set of suppliers. In addition, it is not clear where the initial list of potential suppliers comes from. CyberStamping is operated by the customer. Potential suppliers are invited into a bidding process, possibly from an existing supplier database that a customer may maintain. However, many SMEs do not maintain such databases and therefore a validated pool of potential suppliers has to be provided. From where is not made clear in the paper.
- Commenting on the conceptual basis of CyberStamping, customers may not always be the users of the system. SMEs may wish to take the “initiator” role, by conceptualising a product, identifying potential collaborators, and managing the development and manufacturing project. Hence, SMEs may look for peer “collaborators”, not suppliers, to undertake large-scale projects that they could not possibly undertake on their own. Risks and benefits may then be shared in an open trustful relationship which does not



need an extensive bidding process such as the one Tang et al propose. Such relationships have gain increased research interest by variety of authors such as Harland et al (2004) and Xu et al (2005)

Supply chains, as Tang et al (2004) envision, are mainly represented by links in sequential-horizontal format between the different levels of tiers. Virtual organisations enable the virtual link to also exist in a vertical fashion through collaborations. In this way, a “true” network supply chain is established, which could more accurately be termed a “collaborative supply network”. In this direction are European initiatives such as the European Collaborative networked Organisations LEADership (ECOLEAD) ([www.ecolead.org](http://www.ecolead.org)) and the Assessment of Readiness and Interoperability for Cooperation in New Product Development in Virtual Organisations (ARICON) ([www.aricon.org](http://www.aricon.org)). In particular the ECOLEAD initiative emphasises the need for a suitable ‘virtual breeding environment’ where effective creation of dynamic virtual organisations can take place (Afsarmanesh, 2005). Among the issues and questions posed for further investigation are:

- How to know about the existence of potential partners and deal with incompatible sources of information?
- How to acquire basic profile information about organisations when there is no common format?
- How to build trust among organisations when considered for collaboration?

These are issues that this research has assigned core focus on.

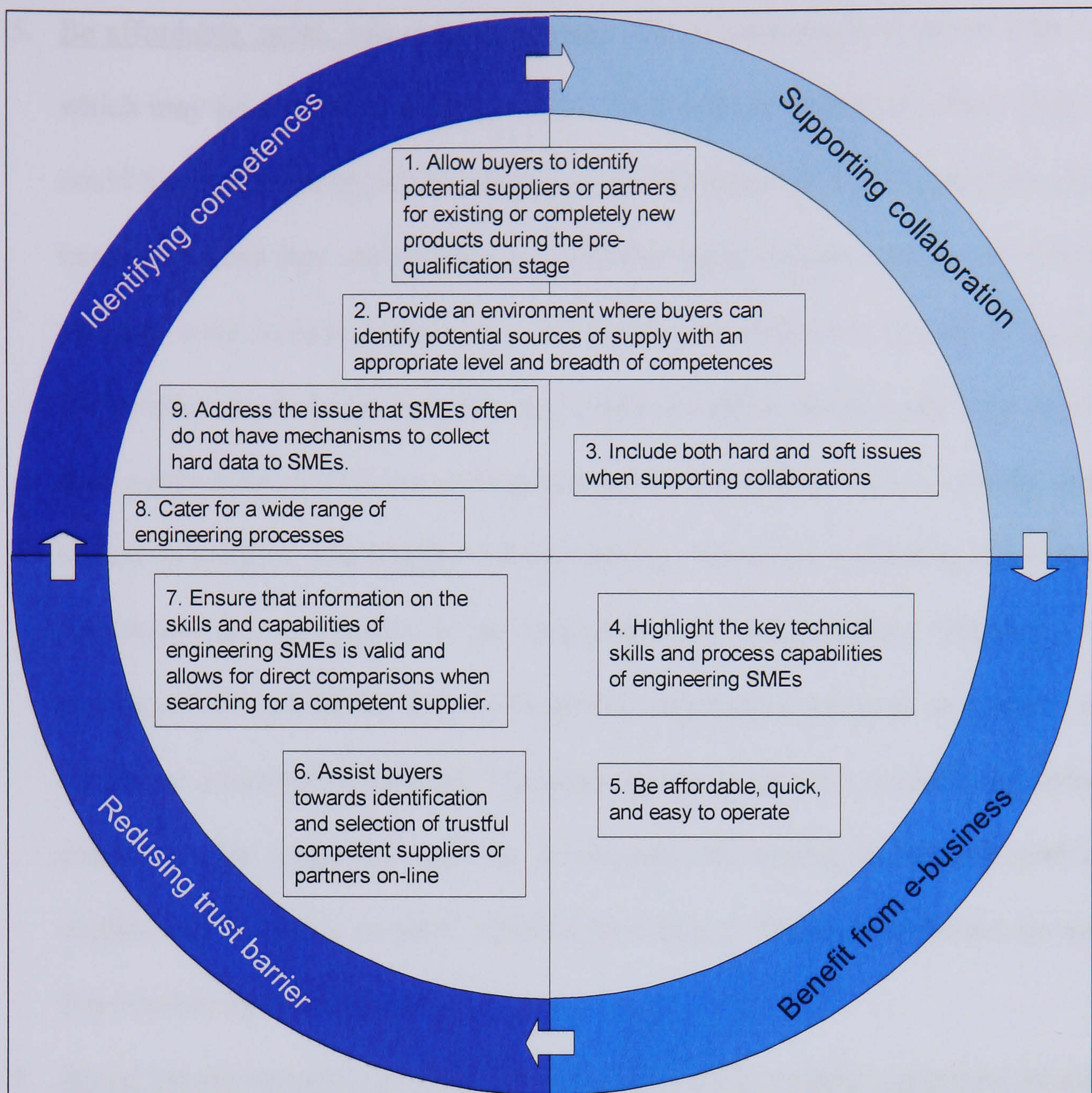


### 3.3 Requirements

In summary, the requirements of a viable solution to enable engineering SMEs to collaborate and operate more effectively in the e-business arena identified by this research are as follows (*Figure 13*):

1. Allow buyers to identify potential suppliers or partners for existing or completely new products during the pre-qualification stage. Internet technologies provide the ability to buyers to increase their sourcing options. They can facilitate finding and transaction with previously unknown business partners, thus generating cost savings through increased market transparency and a more efficient transaction process (Perogianni, 2003). However, on-line identification of suppliers or partners has received less research attention and hence there is a need for methodical investigation and development of a structured solution.
2. Provide an environment where buyers can identify potential sources of supply with an appropriate level and breadth of competences. To achieve this, information regarding key competences of engineering SMEs need to be provided. Access to this information will allow buyers to assess the options available and then select and match complementary competences to form virtual organisations.
3. Include both hard and soft issues when supporting collaborations. The success of collaboration is dependant not only on the obvious and many times quantifiable issues such as availability of a machine with a certain type of capacity. It is also dependant on soft, non-measurable, and unquantifiable issues such as organisational culture. Inter-organisational compatibility needs to be addressed at both hard and soft dimensions.





**Figure 13 Requirements**

4. Highlight the key technical skills and process capabilities of engineering SMEs.

Many SMEs work with highly customised products or ‘one-off’ jobs and as a result the well developed catalogue capability in e-commerce cannot fully represent what engineering SMEs are able to provide. A more complete on-line representation is required which will bring to light the constituent elements that engineering SMEs are based on to build products.



5. Be affordable, quick, and easy to operate. The solution needs to avoid high costs which may be conveyed to SMEs in the form of high registration fees. High fees could hinder the use by SMEs. However, the introduction of cost effective internet based solutions has shown that cost effectiveness requires ability of SMEs to perform tasks on-line on their own. To ensure that SMEs are capable of doing so, the solution needs to be intuitive and usable avoiding at the same time repellent time-consuming procedures such as going through endless lists of criteria, setting values on weights, and lengthy formal training. However, validating affordability, simplicity, and quickness, is an awkward task. Affordability, simplicity, and quickness are qualitative and multivariable dependant concepts and hence, they cannot be accurately measured. The main approach that this research has taken in evaluating the suggested solution is via real life testing in experimental case studies and receiving experts' opinion (sections 2 *Research methodology* and 5 *Implementation and testing*).
6. Assist buyers towards identification and selection of trustful competent suppliers or partners on-line. That is addressing one of the key barriers that e-commerce faces. That of trust and confidence in dealing with suppliers on-line. The issue is not new to the engineering business but is more intense in e-business environment that no physical interaction exists, such as direct observation in supplier's premises, which may assist towards more informed decision.
7. Ensure that information on the skills and capabilities of engineering SMEs is valid and allows for direct comparisons when searching for a competent supplier. Linked with the previous need for reducing the trust barrier, a mechanism needs to be in place that will ensure that provided information regarding the skills and



capabilities is valid. This will ensure that pitfalls of company private website such as outdated information due to poor maintenance are avoided. In addition, to support identification and selection of partners with suitable competences, this mechanism needs to ensure that information among the various companies is consistent and comparable.

8. Cater for a wide range of engineering processes. “Wide” means that the solution needs to be unbounded of a particular engineering process as for instance in the case of CyberStamping (3.2.2 *Partner/supplier appraisal and selection*). This will enable matching of complimentary competences as well as capturing and bringing to light possible innovative and unique engineering processes.
9. Address the issue that there are often no mechanisms in place to collect hard data, such as lead times, and therefore such data is rarely available to SMEs. Many authors, such as Lau and Wong (2001) and Tang et al (2004), have been based on the assumption that such mechanisms exist. However, the author has repeatedly witnessed that this is not the case for many SMEs and hence, dependency on such data needs to be avoided.

An effective solution needs to fulfil these requirements. A methodology to achieve such a solution is proposed and described in the next section.



## 4. Competence Profiling Methodology (CPM)

A methodology has been developed that addresses the core needs identified for:

1. Supporting collaboration
2. Assisting engineering SMEs to benefit from e-business
3. Reducing the trust barrier
4. Identifying competence

In response to these needs, the methodology consists of four main stages, each one addressing a core need:

1. Competence data collection to identify competence
2. Normalising to ensure validity and comparability of information collected from SMEs
3. Making competence information available for e-business
4. Partnership formulation to support collaboration and virtual organisation configuration

The following paragraphs review the main points of each of these stages.

### 4.1 Competence data collection

Competence profiling is utilised to collect competence related information. Competence is defined in this research as the notion that *‘captures the capabilities represented by the key tangible assets, embodied with the abilities of human beings and their key experience and knowledge. It can be interpreted as the company's ability to change and to adapt to different situations or market sectors that have the potential for better profitability’*. Based on this definition a questionnaire has been developed (*Appendix 4*). A more detailed



description and justification of the development of the questionnaire can be found in *Submission 2* in section 3 *Methodology for competence profiling*. The questions assist in capturing the concepts embodied within the definition: key skills, key capabilities, and ability to change and to adapt to different situations.

As argued by authors such as Slack et al (2004), members of staff and facilities are always an integral part of any process, whether this belongs to a manufacturing or service operation. They are part of ‘transforming’ resources that act upon ‘transformed’ resources, such as material and information, to produce products and services. Therefore, it can be assumed that there is at least a minimal technical engineering skill and facilities available for each process. Competence can be viewed as a combination of skills and capabilities. Thus, a process in itself shows varying degrees of competence. Note that many companies can have the same capabilities i.e. the same machinery, the skill element in the competence definition indicates how close to the limits of the machine capability, the company can drive using its skills. Looking at the example of Strata (Flame Cutting & Fabrications) Ltd. (paragraph 1.1 *Background*), more than 10 other companies were found with similar flame cutting and fabrication capabilities during this research. However, it was only Strata that through its people skills and extensive experience could drive hard this capability and undertake profitable flame cutting projects for sculptures.

Based on Ackerman's and Kyllonen's (1991) theory of the existence of three faces of time related relationship between the perceptual/psychomotor activities and the cognitive/intellectual activities, a qualitative gradation of ‘level of processes mastery’ has been defined:



- ‘Basic’, the company has only a basic understanding of the process. It may be relatively new to the company and there is only little operational experience.
- ‘Under development’, a process not operating at full capacity in the company. It is still learned.
- ‘Mature level’, a process fully developed. It is a routine for the company.

Similarly, a qualitative gradation of ‘level of skill’ of key individuals in a company has been also defined. People may be:

- ‘Experienced’ that is to say that they have knowledge acquired through involvement in something over a period of time without any accreditation associated with it
- ‘Certified’, people that have met the knowledge requirements to become accredited for or entitled to a position or privilege
- ‘Expert’, people with experience accompanied by certification

Attention has been also given in capturing soft factors such as company culture which authors, such as Bronder and Pritzl (1992), Trompenaars and Hampden-Turner (2001), and Huang et al (2001), stress that it is important in creating successful collaborations. For instance, a key section in the questionnaire is the ‘company ethos’ where companies are asked to provide a short description of the values of their organisation. Proposed key points include the way:

- customers and employees are treated
- business is done
- people are trained
- attention to detail is given



In finalising the competence questionnaire, three different versions of questionnaires were tested in the twenty Autocle@r companies. The final version was the result of the cumulative experience of the previous versions based on identified problems and difficulties.

During these initial trials it was indicated that remote respondents had many different perceptions of the term competence. Therefore, a high risk of misunderstanding was possible. To mitigate this risk, face-to-face interviews were conducted to help further refine and define the questions.

Issues were also identified during the trial face-to-face interviews. For example, one of the problems was that the interviewees, who were generally individuals with good understanding of the companies' processes and functions, were answering questions only from their personal point of view. This view many times did not represent the organisation as a whole. To alleviate this issue a copy of the filled questionnaire was sent to the interviewee and he/she was advised to circulate it in the company and incorporate possible input from other key individuals.

## 4.2 *Normalising*

This stage enables the estimation of the quality of the identified competences and allows comparisons to be made between the various SMEs. Some of the information collected during the interviews, such as the 'level of process mastery' and the 'level of skill', required subjective judgement. Therefore, the assistance of an expert was considered



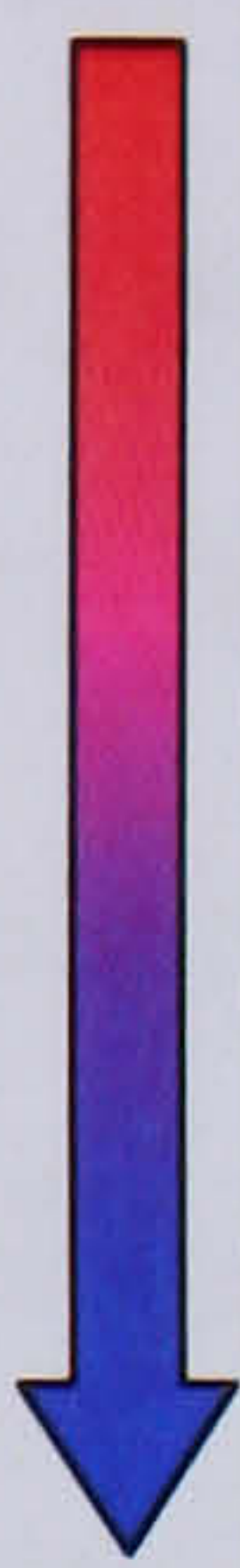
essential within the normalisation process. For instance, the industrial expert employed during the Autocle@r and Autolean projects was Michael Szczygiel from European Automotive Initiative Group, who had interviewed over 150 engineering SMEs in the West Midlands. Michael Szczygiel participated in all conducted interviews ensuring consistency of information collected.

Based on the information provided, the decision maker (e.g. purchasing manager) that seeks a supplier or partner, makes his/her own judgement on whether an organisation's competence fits to the requirements or not. An indication of the quality of competence may be taken from the qualitative gradations provided on process mastery and skill levels. Based on the definitions of 'competence', 'level of process mastery' and 'level of skill' provided in the previous paragraph (4.1 *Competence data collection*), three levels of competence can be defined (*Table 6*). At its 'basic' level, a basic process is supported by non-experts and at its 'distinctive' level a mature process is supported by experts. The intermediary combinations define a 'moderate' level of competence.

The normalisation process serves also as a mechanism for validating the information. This validation assists towards overcoming the issue of trust and confidence between trading parties. Trust and confidence in whether a seller has the ability to provide the appropriate product or service is regarded as one of the major issues that holds e-business back (Preston, 2000; McGarvey, 2001; Perogianni, 2003). Due to the physical presence of experts in profiled companies during the collection of information, the competences of a company are checked. Experts are given the opportunity to walk around a company's premises in order to witness facilities in operation and talk to employees.



Table 6 The three levels of competence defined

		Process capability	Skill
Basic Competence		Pr1	Pe1
		Pr1	Pe1
<div>Level of Competence</div> <div></div>	Moderate Competence	Pr1	Pe2
		Pr1	Pe2
		Pr2	Pe1
		Pr2	Pe1
		Pr2	Pe2
		Pr2	Pe2
		Pr3	Pe1
		Pr3	Pe1
Distinctive Competence		Pr3	Pe2
		Pr3	Pe2
<div>Pr1: Process at Basic Level</div> <div>Pr2: Process at Under Development level</div> <div>Pr3: Process at Mature Level</div> <div>Pe1: People at Experienced Level</div> <div>Pe2: People at Expert level (experienced + certified)</div>			

4.3 Making competence information available for e-business

Competence information becomes accessible on the Internet whereby competences can be searched for and companies that provide them can be discovered. A web-based system has been developed to make the collected competence information available on-line, the Competence Profiling Facility (CPF).

4.3.1 Facility functionality

Users can make keyword searches for skills and process capabilities. Although keyword searches may retrieve records which are irrelevant to what the user wants, they can be beneficial in cases such as:



- When the user is unsure of the exact terminology of the skill or the process that he/she is looking for. A keyword search can help him/her identify records that will help to narrow the search. For example, if a user is looking for processes to produce titanium exhaust manifold system for aircraft, keyword searches around the word “tube” could return processes such as “tube bending”, “cutting” and “welding”. More specific searches on “titanium” or on specific sizes and tolerances would enable the user to identify companies that are able to provide the required titanium exhaust manifold system.
- When the user is looking for skills or processes that are relatively new, novel or unique and may not be exclusively listed in a structured search such as the one built in the partnership search (*4.4 Partnership formulation*). For instance, in the CPF there is only one record available for individuals with “Formula 1” related skills and can be only retrieved by keyword search.

The facility allows the user to make location specific searches by providing him/her the ability to specify the preferred city and/or county. Authors such as Samadhi and Hoang (1998), Zhang (2000) and Porter and Ketels (2003) have emphasised the importance of geographic location in partnerships. Samadhi and Hoang (1998) emphasise the logistical importance as location has direct impact on costs of handling and transportation between partners. Zhang (2000) stresses “proximity to market” as initiators may prefer partners in or close to a geographic target market that they wish to enter. The same author lays emphasis on a location’s good infrastructure and preferential policies. Focusing on clusters, Porter and Ketels (2003) highlight the importance of geographic proximity as it enables easier access to a larger set of specialised resources available from companies,



suppliers, service providers, and associated institutions belonging to the cluster. Geography can also be taken as an indicator of business cultural compatibility. As argued by authors such as Pham (2005) and Overholt (2004), it is more likely to find a partner with a similar business culture locally or in specific places nationally or internationally.

Clicking on the search button, the system returns a list of companies with skills or processes that include the keyword. Company name, location, skills (or processes) are among other information presented on this list (*Figure 14*). Links to the detailed competence profiles are also provided for each of the companies. By accessing the detailed competence profiles, the user can assess the level of relevant competence. Example entries are shown in *Figure 14* and *Figure 15* where it is assumed that there is a requirement for identifying partners to develop a dashboard similar to the one presented in *Figure 16*.

In *Figure 14*, the user is searching in the West Midlands for skills related to keywords ‘CAD/CAM’, ‘injection moulding’, and ‘electrical design’. He/she may also search for processes related to keywords such as ‘injection moulding’, ‘electrical design’ and ‘painting’ (*Figure 15*). The number of results provided is obviously dependent on the keywords used and the number of such entries in the database. By assessing the skill or process details in the resulting list, the user can make a judgement as to whether the companies shown are able to provide the service required. For example, as shown in *Figure 15*, the details provided by Falcon Plastics Co. for their injection moulding process is that it is thermoplastic injection moulding and that the machinery used is a 150 tonne



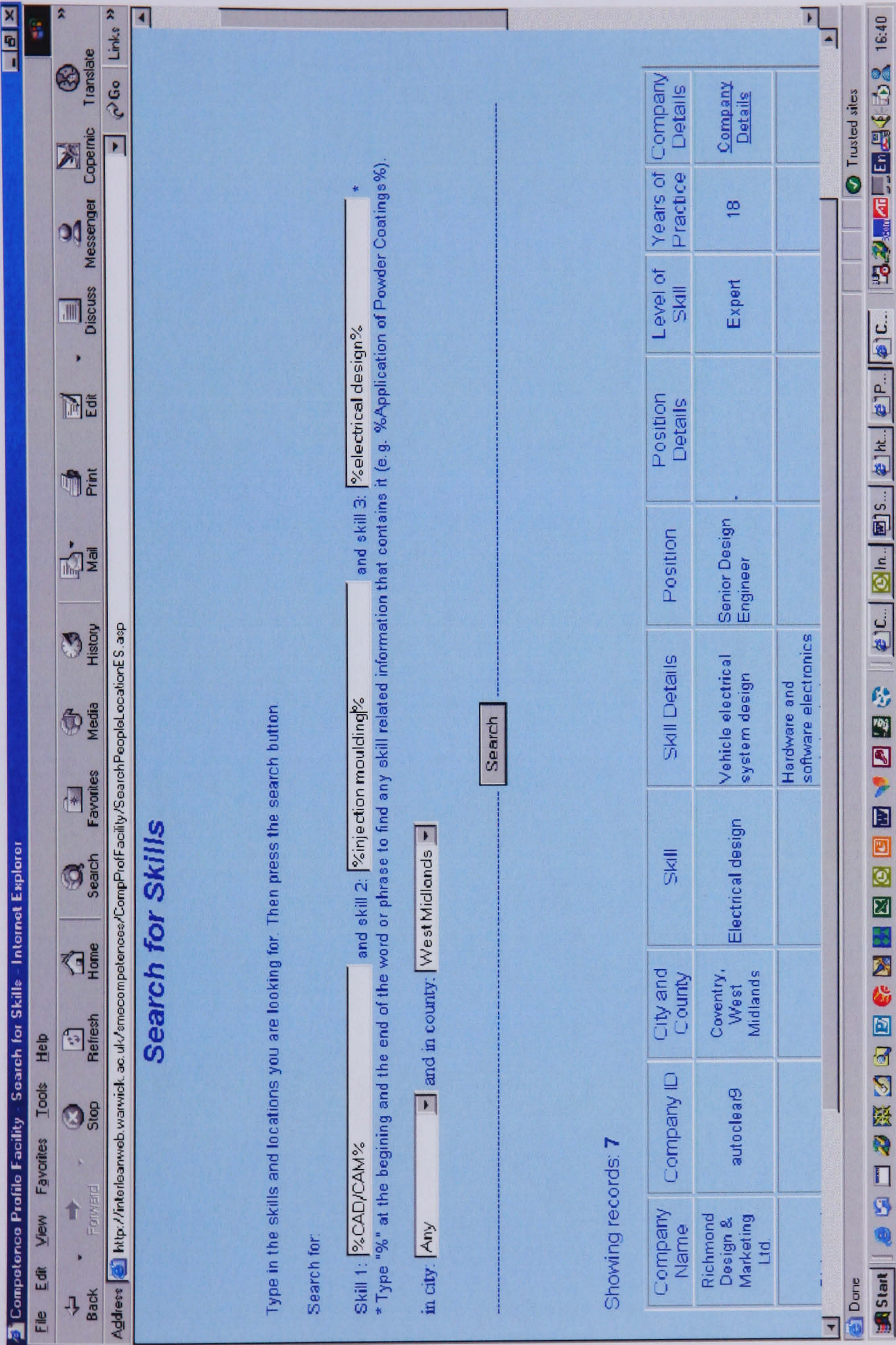


Figure 14 Keyword searches of key skills



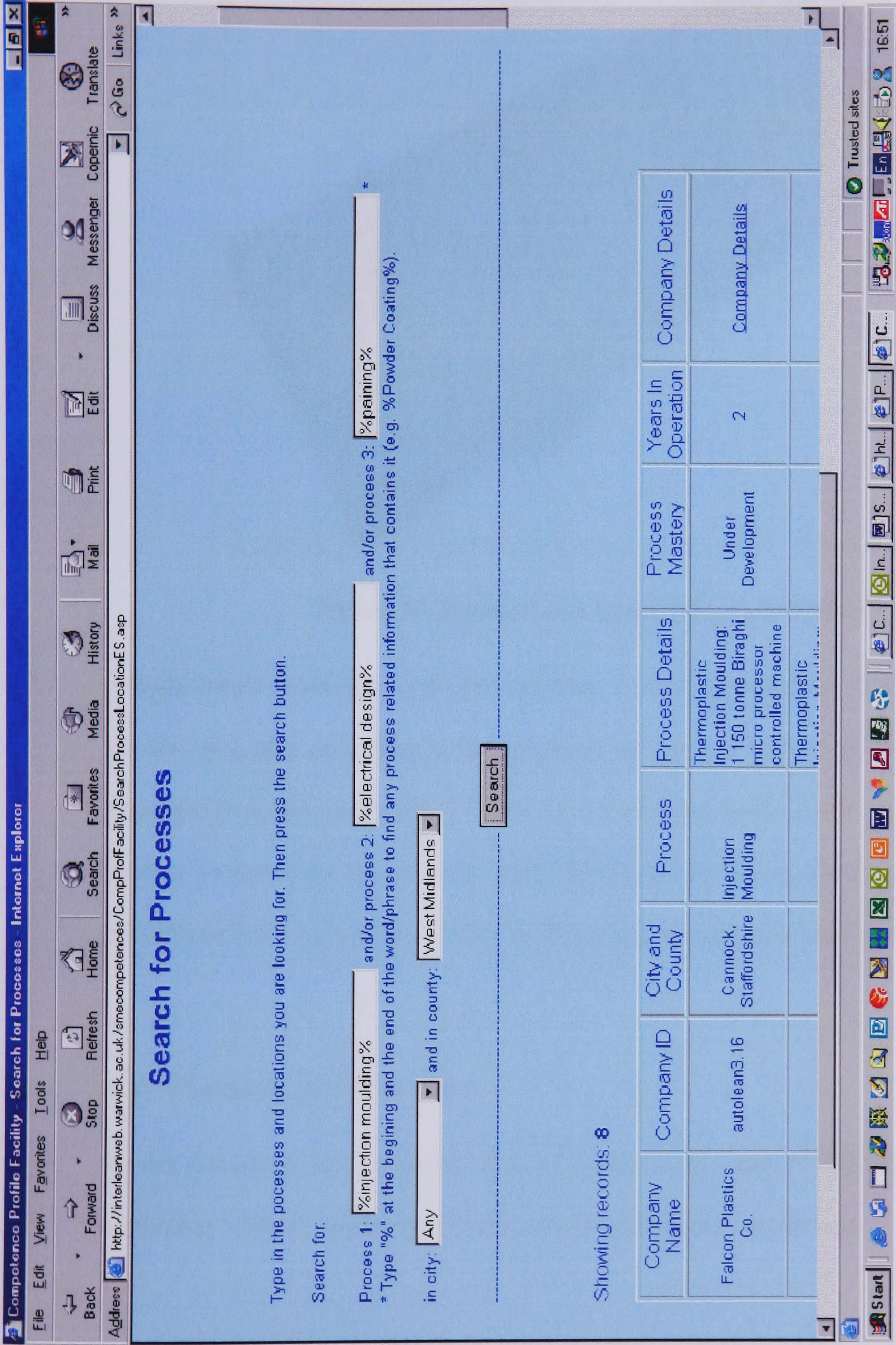
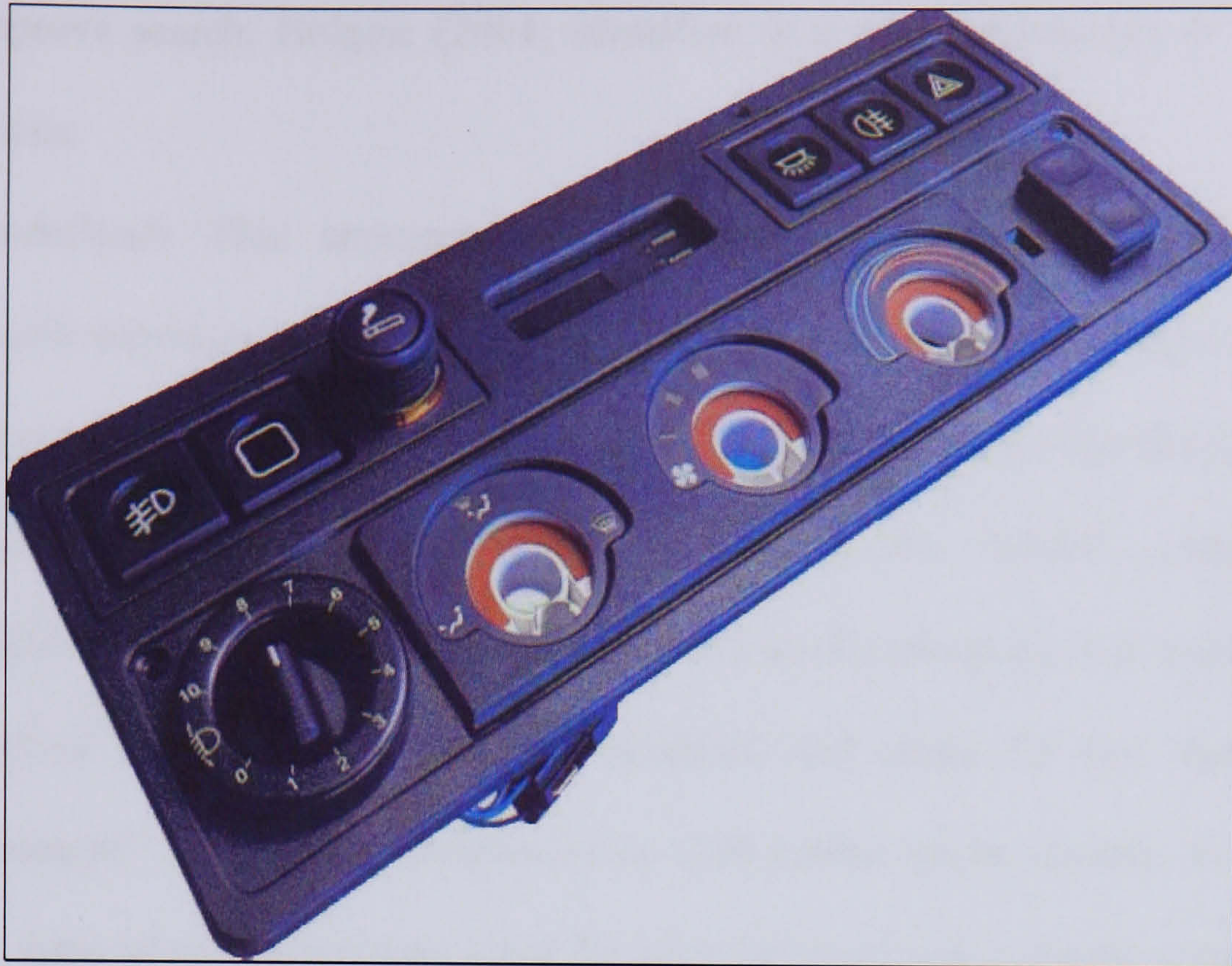


Figure 15 Keyword searches of key manufacturing processes





**Figure 16 Example of a requirement (dashboard)**

Biraghi micro processor controlled machine. Lower down the list is WH Smith & Sons (Tools) Ltd. also providing a thermoplastic injection moulding process. However, this company provides a capacity of 500 tonnes. Company details allow the user to assess the level of competence. For instance, WH Smith provides the injection moulding process at the mature level. This process is driven by an experienced individual (technical manager).

#### *4.4 Partnership formulation*

In this final stage users compile a list of competences required for projects and with the assistance of the Competence Profiling Facility generate partnerships.

A classification of competences is required which would allow users to select the required competences to undertake a project. While developing a method for classifying corporate



data to improve search, Holgate (2004) identified four main approaches of developing classifications:

1. Pre-defined: This approach refers to “pre-built” by various organisations classifications such as the ones provided by e-marketplace operators like First Index (*Figure 5* in page 21) and standardisation organisations like the International Organization for Standardization (IOS) and the NATO Standardisation Organisation (NSO). Although pre-defined classifications provide quick and easy solution as they are industrially validated and ready for use, they take an “averaged” view of how businesses in each market sector operate. For example, the same classification may cater for both furniture and computer manufacturing process. This will frequently cause difficulty in classifying specialised data as an appropriate “category” may not exist.
2. Top down: This approach is user focused. It mainly focuses on the user’s requirements and the needs of the subject area that the classification is to cover. It involves upfront expert advice on what the best categories of a classification are and then continuous manual refinement to best meet the needs of its users. Authors such as Hjørland and Pedersen (2005) and Bailey (1994) regard top down as a “qualitative”, “conceptual”, or “pragmatic” approach because classifications are generally formed without quantification or statistical analysis. Classifications are entirely verbal and conceptual with no empirical cases. With the involvement of a broad range of expertise, an accurate classification is produced which would embrace all data. However, such a process is considered to be labour intensive requiring extensive time.



3. Bottom up: The bottom-up approach first considers the data to be classified and then a classification is created. It is regarded by authors such as Hjørland and Pedersen (2005), Bailey (1994), and Lorr (1983) as a mainly “quantitative” or “positivistic” approach where data are observed and then a classification is formed empirically, usually through numerical analysis of the empirical cases. Due to the complexity of computations required, the use of computer-based algorithms are regarded necessary. For this reason Holgate (2004) terms this approach as “automatic”. Being computerised, the bottom up approach is quicker and less labour intensive as experts are not heavily involved. However, it requires data to be in a numerical format which is not always possible. Competence data, which this research is focused on, are in qualitative form and hence such an automatic approach is not applicable.
4. Hybrid: This is a combination of the ‘top down’ and ‘bottom up’ approaches. As described by Bailey (1994), it is formed by combining the “conceptual and empirical levels of reality”. The hybrid approach may result by either specifying concepts first and then measuring empirical examples or by first forming empirical clusters and then formulating conceptual labels for them. An example of the latter is provided by Holgate (2004) where his proposed hybrid classification technique first automatically creates a concept hierarchy using existing corpus of content that a company may have. It then provides the means to manually evolve by providing an interactive classification editor for experts to create new concepts or change existing to meet their needs.



For the purpose of partnership formulation a classification of engineering processes has been developed where users can choose the processes required to undertake a project (*Figure 17*). With competence data being continuously collected, all data was not available upfront and hence a bottom-up approach to develop this classification could not be employed. A combination of a pre-defined classification with a top down refinement was utilised. Although the pre-defined approach takes an “average” view of the engineering industry and the top down is a labour intensive requiring extensive time, their combination can alleviate these shortfalls. A pre-defined classification would simplify and accelerate the process by providing a basic structure and the top down refinement would cater for specialised competence data.

The predefined classification utilised was the International Classification for Standards (ICS). As stated by the International Organization for Standardisation (IOS, 2001), the ICS is intended to serve as a structure for catalogues of international, regional and national standards and other normative documents, such as standards, technical reports, standardised profiles, technical specifications and technical regulations. Being an internationally recognised and validated standard, the ICS provided a basis for defining the list of engineering processes at generic level. However, seeking to bring to light the companies’ competences, the classification was continuously refined and detailed to reflect on the competences identified. For instance, “pre-treatment cleaning and chemical anti-corrosion” was not specified in the ICS but was a key process available by a profiled company.



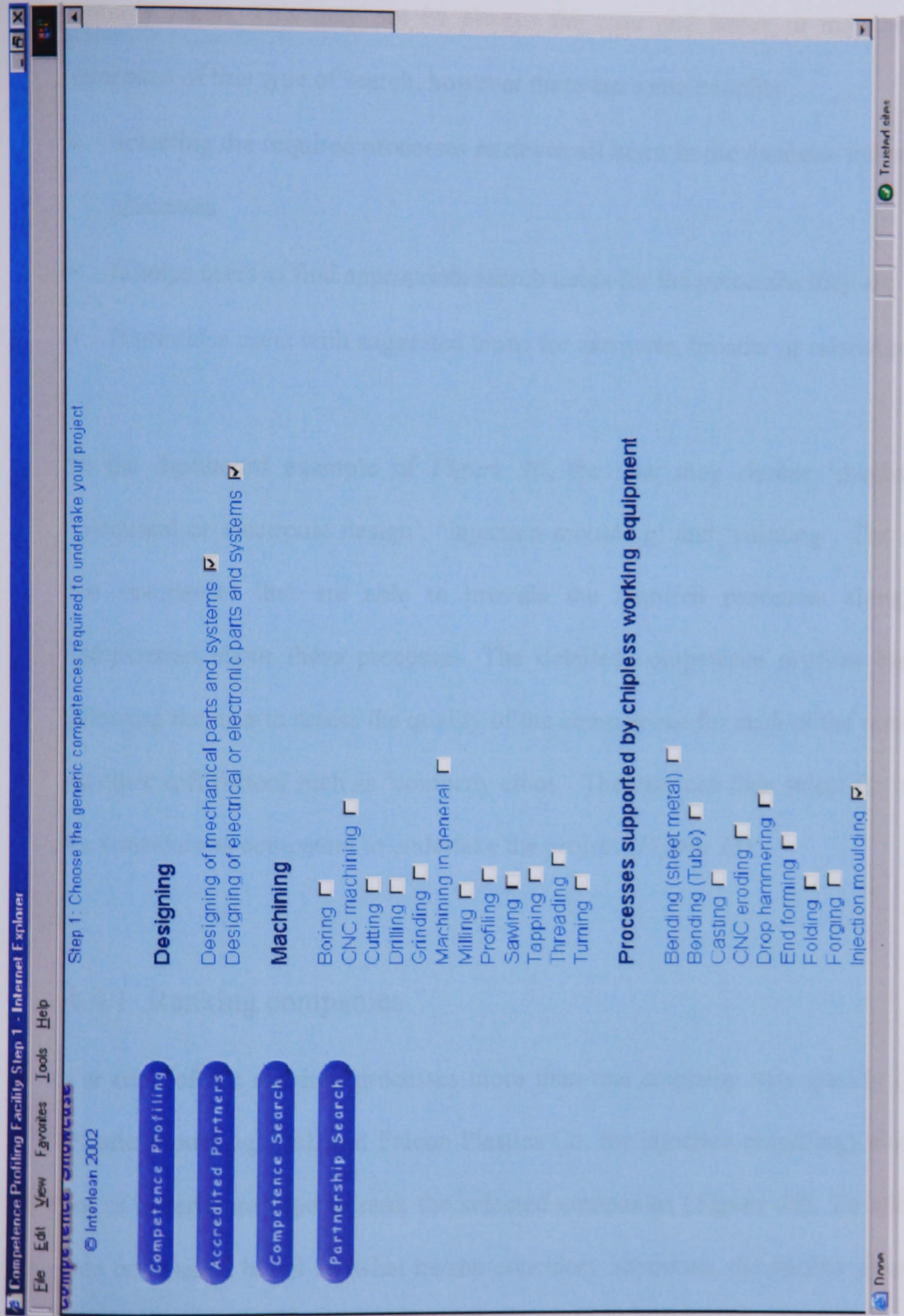


Figure 17 Selection of engineering processes



To be usable such a process list requires users to understand what the process names actually mean. This may not be always the case and hence, it may be counted as a weakness of this type of search, however there are some benefits:

- Selecting the required processes retrieves all items in the database indexed under these processes
- It helps users to find appropriate search terms for the processes they are looking for
- It provides users with suggested terms for narrower, broader or related processes

In the dashboard example of *Figure 16*, the user may choose ‘mechanical design’, ‘electrical or electronic design’, ‘injection moulding’ and ‘painting’. The system returns the companies that are able to provide the required processes along with further information about these processes. The detailed competence profiles can be accessed allowing the user to assess the quality of the competence for each of the companies as well as other soft factors such as ‘company ethos’. The user can then select the companies that he considers as competent to undertake the project (*Figure 18*).

#### 4.4.1 Ranking companies

For each of the required processes more than one company may qualify (e.g. European Plastic Mouldings Ltd. and Falcon Plastics Co. for injection moulding). For this reason a set of criteria are used to rank the selected companies (*Figure 19*). To allow the user to rate companies based on what he/she considers important, the facility allows the user to first prioritise criteria and then to allocate value for each of them. The criteria employed are:



Competence Profiling Facility Step 2 - Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh

Search Home Favorites Media History Mail Print Edit Discuss Messenger Copernic Translate

Go

Links

Address http://interleanweb.warwick.ac.uk/smecompetences/CompProfFacility/CompExSysStep2.asp

InterLean

Competence Showcase

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Competence Profiling Step 1

Step 2: Choose the companies that fulfill the required competences. More than one company can be chosen for each competence.

Showing records: 48

Key Process	Process Details	Company Name	Company Details
Electrical or electronic designing	Designing and simulation	Richmond Design & Marketing Ltd.	<a href="#">Company Details</a>
Injection Moulding	Polymemory (see in "competence transfer" section for further details)	European Plastic Mouldings Ltd.	<a href="#">Company Details</a>
Injection Moulding	Plastic Injection Moulding. - Insert MouldingRanging from polypropain to naylorons to polycarbonate. Machinery: Boy 50M, Stubbe 55 tn, Negri Bossi 25 tn	European Plastic Mouldings Ltd.	<a href="#">Company Details</a>
Injection Moulding	Thermoplastic Injection Moulding: 1 150 tonne Biraghi micro processor controlled machine	Falcon Plastics Co.	<a href="#">Company Details</a>
Injection Moulding	Lost core injection moulding	Siemens Automotive Systems Ltd.	<a href="#">Company Details</a>
Injection Moulding	Thermoplastic Injection Moulding: 1 50 tonne Boy microprocessor controlled machine	Falcon Plastics Co.	<a href="#">Company Details</a>
Injection Moulding	Thermoplastic Injection Moulding: 1 30 tonne Boy micro processor controlled machine	Falcon Plastics Co.	<a href="#">Company Details</a>
Injection Moulding	95 machines with capacity range of 30 tonnes to 500 tonnes	WH Smith & Sons (Tools) Ltd.	<a href="#">Company Details</a>

Trusted sites

Start http://www.in... Competen... SupEleComC... http://www.in... 18:55

Figure 18 Selection of companies



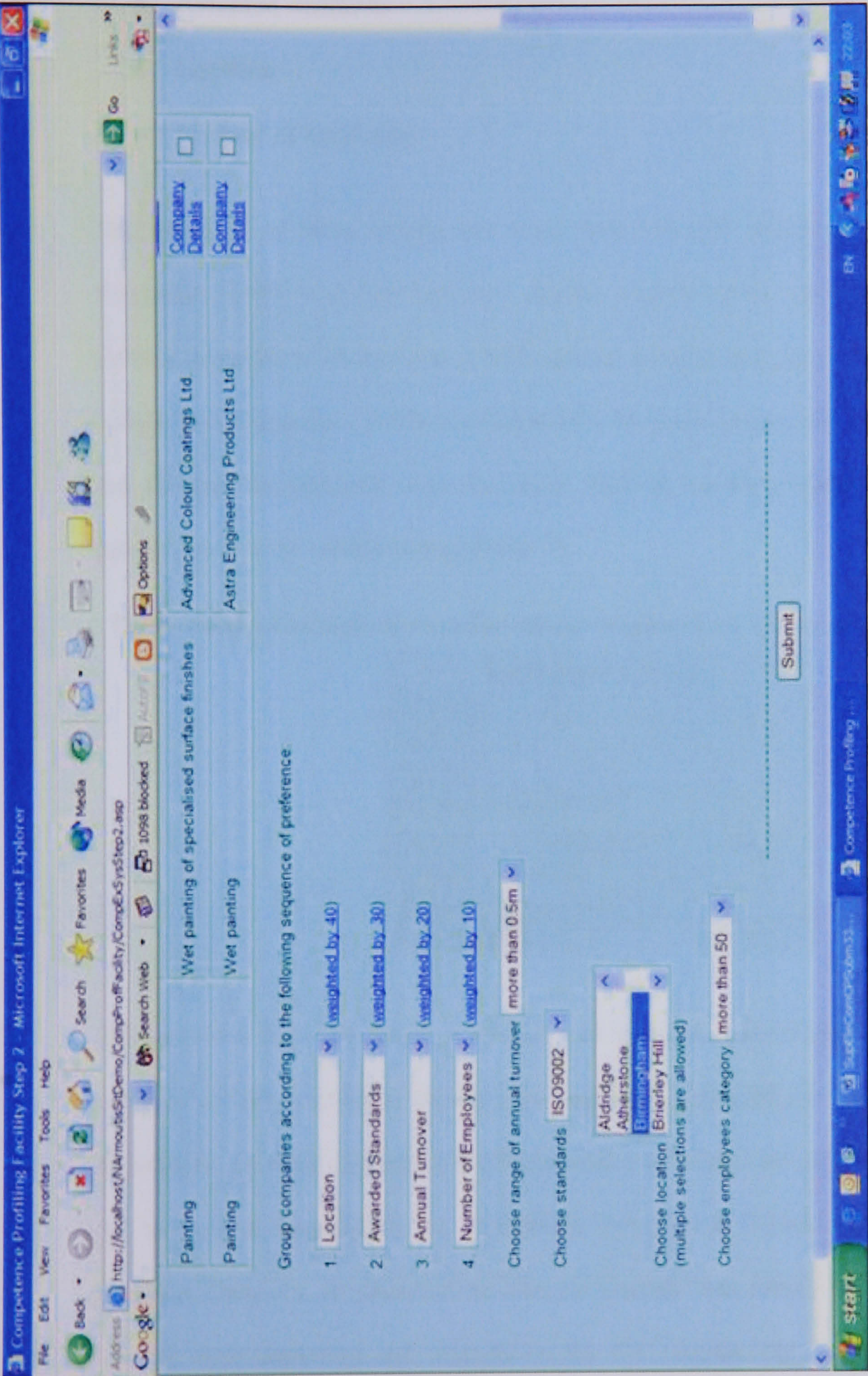


Figure 19 Selection of criteria priority and allocation of values



- Annual turnover
- Awarded standards
- Location
- Number of employees

The selection of these criteria has been based on the collective work of Yahya and Kingsman (1999) on vendor selection criteria. Examining the pioneering work of Dickson (1966), the work of Weber et al (1991), and an exercise in a major engineering company, Yahya and Kingsman (1999) concluded that the basic criteria for vendor selection have not changed significantly over the years. Relying on these, they established a list of generic criteria for vendor rating (*Table 7*).

**Table 7 List of criteria for vendor rating employed by Yahya and Kingsman (1999)**

Evaluation Criteria
Delivery
Quality
Facility
Technical Capability
Quality of Management
Financial position
Attitude (discipline)
Responsiveness

The selection and refinement of criteria was based on consultation with the creator and organiser of the Institute of Mechanical Engineers (IMECHE) Awards for Manufacturing Excellence, Dr John Garside. First Dr Garside was briefed about the overall objectives of the study then specifically on partnership formulation. Yahya and Kingsman’s set of potential criteria were presented to him. Dr Garside was simply asked to indicate which criteria were important and relevant to the UK engineering sector and add any other criteria or sub-criteria that might be useful. Having significant knowledge and experience



on vendor rating via his work as a senior manager of Lucas Aerospace as well as a creator of the IMECHE awards, the interview lasted no more than one hour. All eight criteria suggested by Yahya and Kingsman were considered important. However, after discussion between Dr Garside and the author, four criteria were selected to be used at this particular stage of the partnership formulation. These were ‘delivery’, ‘quality’, ‘financial position’, and ‘responsiveness’. ‘Facility’ and ‘technical capability’ were considered to be examined by users before selecting priority criteria, when judging and selecting the suitable processes available by companies (*Figure 18*). ‘Quality of management’ and ‘attitude’ were mainly regarded as qualitative criteria which could not be easily allocated with accurate values. Therefore, they are assessed when accessing the full profile of companies and in particular in descriptive sections such as ‘company ethos’ and ‘mechanisms to ensure continuous improvements’.

- ‘Awarded standards’ was selected as a simple and quantifiable indication of companies’ ‘quality’ of products and services. Quality was viewed as a “consistent conformance to customers’ expectations” (Slack et al., 2001: p684). ‘Conformance’ implies need to meet specification and ‘consistent’ that the resources such as facilities and processes have been designed to ensure that the product or service meets specifications. ‘Customer expectations’ implies that products or services are fit for their purpose and that the price of a product or service meets the value that a customer receives. Awarded standards were viewed as an indication of a company’s active engagement in meeting customer expectations and supporting conformance and consistency, as well as an inspiration to work toward process and skill improvement.



- ‘Location’ in combination with the ‘number of employees’ category was selected as an indication of on-time ‘delivery’ and likelihood of prompt ‘responsiveness’. The logistical importance of location as well as in partnership compatibility in general have been also pointed out by authors such as Samadhi and Hoang (1998) and discussed in previous paragraph (paragraph 4.3). Prompt response has been also linked with the workforce capacity of a company. Authors such as Breu et al (2002) have stated the importance of the workforce in responsiveness in context of change. Simply stating ‘number of employees’ may not provide enough information to allow safe judgment on the responsiveness of a company. However, it is an indication which if combined with more detail information available in the competence profile such as key skills, processes, and competence transfer, safer judgments can be made. In addition, ‘number of employees’ serves another purpose. Being an indication of the size of an organisation, it points to the type of culture an organisation has. As an example, Connell found, a positive organizational culture and higher morale workforce is more likely in smaller companies as a result of senior management close interaction with employees (Connell, 2001).
- ‘Annual turnover’ was selected as an indication of the ‘financial’ strength and size of the operations. Although the financial position may have been better expressed by profit indications, it was believed that many SMEs would be reluctant to provide such information that would be available on the Internet. Subsequent experience indicated that many SMEs were indeed reluctant to provide any information about their financial position, even their annual turnover. Around 10% of the interviewed companies would not provide information about their annual turnover. In addition, an in depth analysis



of the financial position of the companies is out of the scope of this study whose main focus is on key technical competences. For these reasons this criterion has been omitted in the new system discussed in paragraph 5.3 (*The West Midlands Collaborative Commerce Marketplace (WMCCM)*). Instead the importance of market familiarity as stated by Hitt et al (2000) (see *Table 5* in 3.2.2 *Partner/supplier appraisal*) has been taken into consideration. Therefore, ‘markets’ and ‘reference customers’ have been added in the set of criteria. This modification takes into account the importance of understanding the specific requirements of a particular supply chain and being familiar with a sector’s culture.

#### 4.4.2 Method of appraisal

Having defined the criteria of assessment, the next step is determining the method of partner appraisal to be used. Based on the analysis made in section 2.2 *Supplier appraisal* in *Submission 2*, four main categories of appraisal methods were identified in the literature:

1. Cost-based methods. Cost-based methods evaluate suppliers by first calculating the total cost of doing business with suppliers. Costs associated with areas such as quality, delivery and service are calculated (Jayaraman et al., 1999), (Youssef et al., 1996).

Cost-based methods provide explicit and understandable arithmetic ratings. Due to their cost orientation, they are particularly preferable in cases where decisions are determined by cost. However, translating all aspects of supplier's performance and especially qualitative criteria into precise cost figures is a complex task requiring a



comprehensive cost accounting system. For instance, Youssef et al (1996) in modelling cost of quality and responsiveness, they needed to make four key assumptions and determine more than ten variables to make a cost estimation. Furthermore, cost estimation is mainly based on quantitative data such as defect items and lead time which are not available to many SMEs.

2. Categorical methods. Categorical methods are, in general, intuitive and simple. Suppliers are appraised on each criterion in categorical terms such as good, neutral and unsatisfactory (Youssef et al., 1996). Partners are then ranked based on the total number of criteria scored as good, neutral, or unsatisfactory.

Categorical methods are easy and provide a clear and systematic way of supplier assessment, especially when qualitative criteria are involved. They are inexpensive and require a small amount of data. However, as Nydick and Hill (1992) state, they do not clearly define the relative importance of each criterion and the decisions made tend to be fairly subjective. Yahya and Kingsman (1999) consider categorical methods as the least precise of the evaluation techniques.

3. Linear-weighted methods. Linear weighted methods are an extraction of the categorical methods. A set of weights are also used indicating the relative importance of each criterion. The weights may add up to unity or 100% and total scores can take values within a specified range. The general function used to determine the total score of supplier (i) is:



$$TS(V_i) = \sum_{j=1}^n W_j S_{ij}$$

where:

$S_{ij}$ : the score for vendor (i) on attribute (j)

$W_j$ : weight of attribute (j)

Linear weighted methods are potentially more precise than the categorical methods, they are more flexible and without the accounting demands of the cost-based methods (Yahya and Kingsman, 1999). The subjective assignment of weights to each of the criteria and the requirement for experienced management for good value judgment are the main shortcomings. Moreover, many of these methods may require significant time for assigning appropriate weights. They may also require a certain level of knowledge of mathematics in order for the user to have a better understanding of how the method functions. However, a simple linear weighted method could be an attractive option.

4. Analytic hierarchy process methods. Similarly to linear weighted methods, analytic hierarchy process methods deal with multi-criteria decision problems by allocating weights through subjective assessment. The method allows the decision maker to structure complex problems in the form of a hierarchy (Nydick and Hill, 1992). It provides a more systematic process for determining the weights. Three steps are primarily involved in this method (Yahya and Kingsman, 1999):



- Structuring the problem hierarchy: the hierarchy has at least three level which include the goal (the best overall supplier), the criteria (such as quality, delivery, and cost), and the alternatives (alternative sources of supply).
- The evaluation process: it involves the formulation of the questions to be used to generate the comparisons between the elements of the hierarchy. The decision maker allocates values by comparing the elements in pairs.
- The calculation of the weights: this is often done by solving the ‘eigenvalue problem’.

Although AHP methods appear to be preferred due to their simplicity, accuracy, formality and systematic approach, they have some shortcomings. Face to face discussion and training over the methodology, which according to Yahya and Kingsman (1999) are required for obtaining good results, require time and effort. Busy managers may find it inconvenient to commit themselves to such a process. The approach may be even more difficult to apply in the engineering SME environment where time and appropriate skills are not always available.

Based on requirements for simplicity and quickness in use, a simple linear weighted method was regarded as the most suitable. With the user prioritised criteria (*Figure 19*), the system automatically allocates weights to each of them. This automatic allocation of weights does not give flexibility to the user to determine arithmetically and more accurately the relative importance that he/she perceives of a criterion over another one. However, it simplifies and makes the process more intuitive.



In order to define the relative importance of each criterion, the weights add up to 100. The first priority criterion is weighted 40, the second 30, the third 20, and the fourth 10. The linear-weighted method function  $TS(V_i)$  (point 3 *Linear-Weighted Methods*) is used to determine the total score of the selected company with  $S_{ij}$  taking values 1 if true and 0 if false.

In the dashboard example, the criteria have been prioritised with the following sequence:

1. Location (Birmingham and Coventry)
2. Awarded standards (ISO 9002)
3. Annual turnover (more than £0.5 million)
4. Number of employees (more than 50)

Therefore, the selected companies that:

- are within Birmingham and Coventry are allocated with a weight of 40
- are awarded with ISO 9002 are allocated with a weight of 30
- have annual turnover more than £0.5 million are allocated with a weight of 20
- have more than 50 employees are allocated with a weight of 10

The total scores for each of the selected companies are then calculated based on the  $TS(V_i)$  function.

#### 4.4.3 Weight estimation

The weights utilised have been based on data from the Manufacturing Excellence (MechEx) competition information derived by Dr John Garside. The logic behind these values is based on the assumption that when a user prioritises the criteria, he/she sets the following relations:



- The first priority criterion is 4 times more important than the last one
- The second priority criterion is 3 times more important than the last one
- The third priority criterion is 2 times more important than the last one

For instance, the selected sequence of criteria preference of *Figure 19* is described by the following statements:

- ‘Location’ is 4 times more important than the ‘number of employees’
- ‘Quality’ standards is 3 times more important than the ‘number of employees’
- ‘Annual turnover’ is 2 times more important than the ‘number of employees’
- ‘Number of employees’ has the same importance as the ‘number of employees’

These statements can be expressed by the following mathematical expressions:

- $W_1 = 4 W_4$
- $W_2 = 3 W_4$
- $W_3 = 2 W_4$
- $W_4 = 1 W_4$

Where  $W_i$  is the weight for criterion  $i$  with  $i = 1, 2, 3, 4$

Considering also  $W_1 + W_2 + W_3 + W_4 = 100$ , then the following system of equations is formulated:

$$W_1 = 4 W_4$$

$$W_2 = 3 W_4$$

$$W_3 = 2 W_4$$

$$W_1 + W_2 + W_3 + W_4 = 100$$

The solution of this system provides the following weights:



$$W_1 = 40$$

$$W_2 = 30$$

$$W_3 = 20$$

$$W_4 = 10$$

To assess further the validity of these weights, a procedure of estimating weights based on the ‘ratio-scale pair-wise comparison matrix’ has also been followed. The procedure has been successfully implemented by authors, such as Nydick and Hill (1992) and Akarte et al (2001), while studying the application of the Analytical Hierarchy Process to structure the supplier selection process. According to this procedure a set of pair-wise comparisons among the various criteria are made. These comparisons are expressed with numerical values that define the ‘ratio-scale pair-wise comparison matrix’. For instance, if a user believes ‘very strongly’ that location is a more important criterion than the number of employees in a company, then ”four” represent this preference. The scale used to quantify comparisons is shown in *Table 8*. The same scale ratings have been utilised by Nydick and Hill (1992) and Akarte et al (2001).

**Table 8 Numerical rating of user preferences**

User Preference	Numerical Rating
Equally preferred	1
Moderately preferred	2
Strongly preferred	3
Very strongly preferred	4

If the sequence of criteria preference is as shown in *Figure 19*, then according to the numerical rating of *Table 8* the pair-wise comparisons are:



- ‘Location’ compared to ‘number of employees’ is 4
- ‘Quality standards’ compared to ‘number of employees’ is 3
- ‘Annual turnover’ compared to ‘number of employees’ is 2
- ‘Number of employees’ compared to ‘number of employees’ is 1

Since the pair-wise comparison of ‘location’ to ‘number of employees’ is 4, or equally a 4 to 1 ratio, it follows that the pair-wise comparisons of ‘number of employees’ to ‘location’ is a 1 to 4 ratio, or 1/4. Similarly:

- ‘Number of employees’ compared to ‘quality standards’ is 1/3
- ‘Number of employees’ compared to ‘annual turnover’ is 1/2
- ‘Quality standards’ compared to ‘annual turnover’ is 3/2

In the same manner all the pair-wise relationships are defined. The full pair-wise comparison matrix is shown in *Table 9*. It is important to note that the elements of the matrix remain the same whatever the sequence of the criteria preference is. Each time a user specifies a sequence of preference, he/she specifies what the first, second, third, and fourth criterion of the comparison matrix of *Table 10* is.

**Table 9 Example of ratio-scale pair-wise comparison matrix**

	<b>Location</b>	<b>Quality Standards</b>	<b>Annual Turnover</b>	<b>Number of Employees</b>
<b>Location</b>	1	4/3	2	4
<b>Quality Standards</b>	3/4	1	3/2	3
<b>Annual Turnover</b>	1/2	2/3	1	2
<b>Number of Employees</b>	1/4	1/3	1/2	1



**Table 10 The ratio-scale pair-wise comparison matrix for the Competence Profiling Facility**

	1 <sup>st</sup> Criterion	2 <sup>nd</sup> Criterion	3 <sup>rd</sup> Criterion	4 <sup>th</sup> Criterion
1 <sup>st</sup> Criterion	1	4/3	2	4
2 <sup>nd</sup> Criterion	3/4	1	3/2	3
3 <sup>rd</sup> Criterion	1/2	2/3	1	2
4 <sup>th</sup> Criterion	1/4	1/3	1/2	1

According to Golany and Kress (1993), a ratio scale matrix  $D= (d_{ij})$  has consistent preference intensities when:

$$d_{ij} = d_{ik}d_{kj} \text{ for all } i,j \text{ and } k$$

The comparison matrix of *Table 10* has consistent preference intensities. Evaluating a series of methods for obtaining weights from ratio-scale matrices, Golany and Kress (1993) argue that if a ratio scale matrix  $D= (d_{ij})$  has consistent preference intensities, then weights are readily available by taking any column of the matrix  $D$  or constant multiple of them. Therefore, being a constant multiple of the columns of the comparison matrix in *Table 10*,  $W_1 = 40$ ,  $W_2 = 30$ ,  $W_3 = 20$ , and  $W_4 = 10$  are valid weights.

In the final step of the Competence Profiling Facility (CPF) the system returns a proposed group of companies that could undertake the project. In *Figure 20* the proposed group of companies for the dashboard example is presented. This group consists of companies with the best total scores for each of the key processes selected. Such a rating technique formalises the process of identifying partnerships. With many companies available for each process and many criteria to appraise them, the complexity of such a decision is far too high and hence a more formalised and systematic method is necessary. In addition, the rating technique employed adds flexibility by avoiding rigid searches with absolute values that often bring irritating nil results. It also enables a ranking list of alternative companies to be provided. This provides users with prioritised alternatives, available in case a suggested partner for any reason is unable to participate in the suggested partnership.



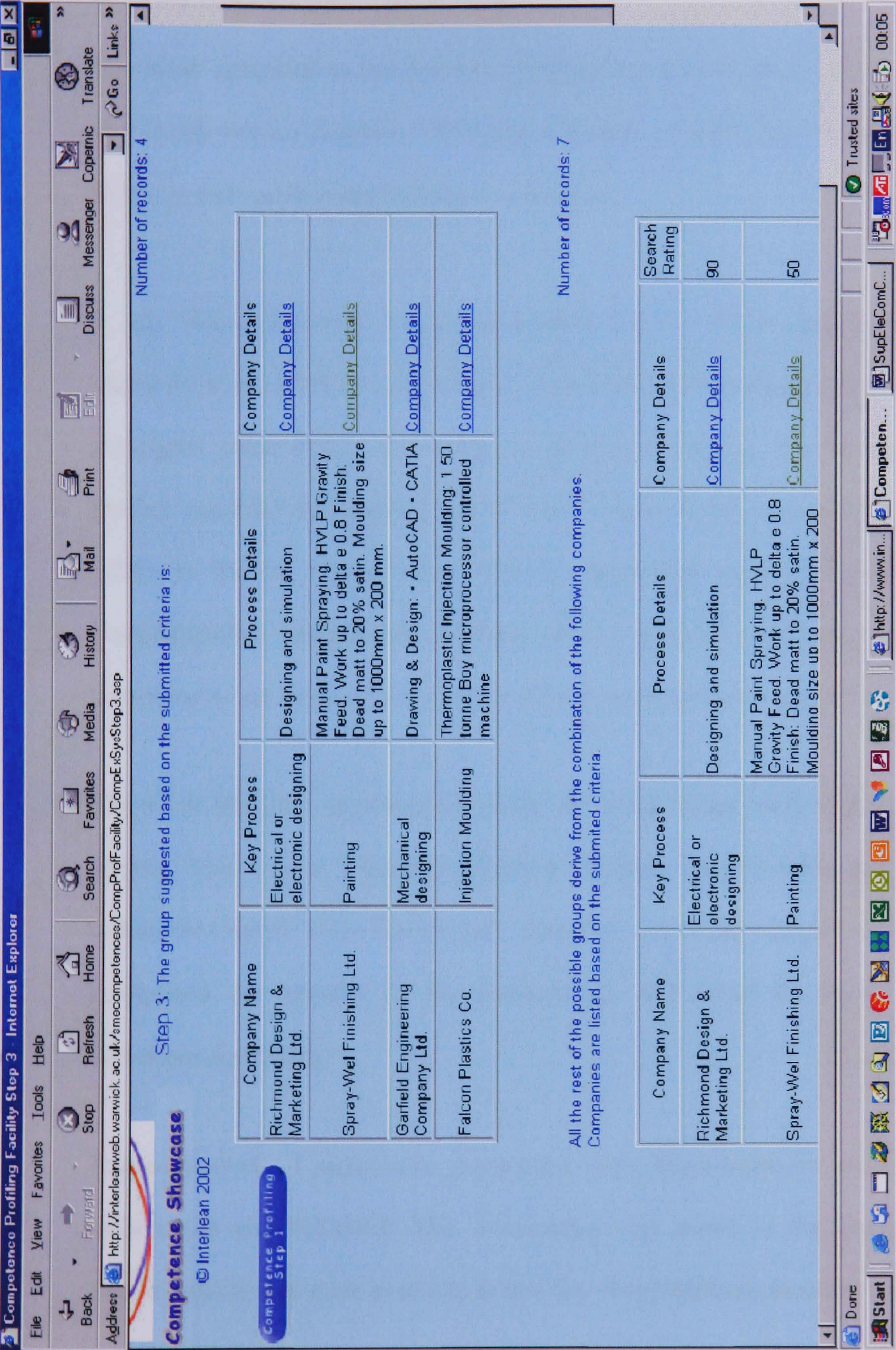


Figure 20 Proposed group of companies that could undertake the project and a ranking list of alternative companies



## 5. Implementation and testing

The ideas described in the previous paragraphs were tested and fine-tuned through the Autocle@r and the Autolean 3 SME development projects. Over one hundred engineering SMEs in total participated in these two projects.

A key objective of the Autocle@r project was to “allow participants to utilise the resources of the Internet to facilitate co-operation between suppliers to enable them to bid for higher value work”. To satisfy the demand for higher level systems and complete project capability demanded by 0.5, 1<sup>st</sup> and 2<sup>nd</sup> tier automotive suppliers, the CPM enables SMEs to bid for higher value work by suggesting groups of project partners with complementary competences. Starting from a project's requirements, the appropriate competences are matched and a group of partners by project is proposed.

The CPM was also implemented within the scope of the main objective of Autolean 3 project. This was to “introduce practical business Internet skills and experiences into automotive supply chain businesses”. Sixty-two out of the eighty-five SMEs approached recognised the benefits of the methodology and chose the option of undertaking competence profiling.

Representatives of eighty-two companies were interviewed in total and competence information was collected. This information was stored in the Competence Profiling Facility which was made available to two key West Midlands business portals:



- Go4Gain (at [www.go4gain.co.uk](http://www.go4gain.co.uk)). Go4Gain was supported by Warwick University, the European Union through the European Regional Development Fund (ERDF), DTI through the Regional Development Agency (Advantage West Midlands) and key regional OEMs such as Peugeot and Jaguar.
- 2WM (at [www.2westmidlands.com](http://www.2westmidlands.com)). 2WM is a business-to-business e-portal developed in partnership with the Regional Development Agency (Advantage West Midlands), BT, Coventry University and the European Commission.

The companies registered to CPF were also registered on the Go4Gain on-line business directory.

The Competence Profiling Facility appeared on the Google and Yahoo World Wide Web (WWW) search engines making accessibility to the facility easier. Searches in these engines for keywords such as ‘competence facility’, ‘competence profiling’, and ‘competence SMEs’, or even a name of a company registered to the facility, brought the facility to the top of search results.

Several demonstrations have been made to SME representatives such as Mr Thomas Dodd from Frederick Woolley Ltd, as well as to purchasing and IT experts such as Mr Malcolm Bird from GKN and Mr Martin Ready from Sun Microsystems. Useful feedback was gained through these demonstrations, which enabled further improvement of the system and stimulated the interest for alternative implementations. For example, a variation of the methodology was then accepted for the Manufacturing Advisory Service - West Midlands (MAS-WM). A more comprehensive testing of the methodology is currently being



conducted with the West Midlands Collaborative Commerce Marketplace (WMCCM) (paragraph 5.3), the Plasteem European framework 5 project for plastics suppliers, and the GatewayAsia portal funded by London development Agency to help link Indian and London region SMEs.

### *5.1 Benefits of the methodology*

The implementation of the developed methodology proved to have several benefits. In summary these are as follows:

- Information about an engineering company's capability can be accessed by potential local, national, and international customers
- Engineering SMEs can be considered for partnership in complex multi-partner projects based on publicised competences
- Buyers can electronically search, identify, compare, and match new alternative sources of supply
- The system developed allowed buyers to identify with increased confidence a suitable supplier or group of suppliers by their competences
- The methodology aids engineering SMEs by assisting them to collaborate and by providing them with the ability to apply their competences in fields or locations that may be more profitable
- No formal mechanisms for measuring the performance of a company are required, such as on-time delivery and warranty claims, usually found in supplier assessment methodologies



- The system was offered by the Go4Gain and the 2WestMidlands (2WM) portals with no charges to SMEs
- The system requires only basic experience in operating web browsers and in contrast with many supplier selection systems, users are not required to go through time consuming procedures, endless lists of criteria, and setting values on weights

In addition to the benefits identified, the methodology has also indicated some key difficulties. In summary, the key difficulties of the approach taken are as follows:

- Effort has to be made to collect competence information via structured interviews and validation visits which usually is a costly process (discussed further in paragraph 5.3.3 and 6.3.3 )
- Normalisation is based on an individual and therefore there is subjectivity in the process (discussed in paragraphs 6.3.3 and 6.3.4)
- The user of the system needs to have knowledge and experience of the various engineering processes to select the competences needed (discussed in paragraph 6.3.3)
- It is assumed that companies are keen to disclose their information on the Internet which some times is not the case (discussed in paragraphs 5.4.4 and 6.3.3)

Building on the identified benefits, further developments were made to minimise the weaknesses. These are described within the following update.

## *5.2 Further implementation and testing*

Since its development and implementation through the Autocle@r and Autolean 3 projects, the CPM has attracted the interest of several organisations and institutions. This



interest varies from independent engineering SMEs wanting to be profiled and registered on the Competence Profiling Facility (CPF) to organisations willing to adopt and implement these ideas to their specific needs. Examples of the former are Hammond Heat Treatment Ltd and Mitchell Cotts Transmissions Ltd (*Figure 21*) which requested registration. The latter includes organizations such as:

- The Manufacturing Advisory Service – West Midlands (MAS-WM)
- Advantage West Midlands (AWM)
- Northern Defence Industries (NDI)

Hi Nikolaos,

Whilst searching on the web for a supplier of ours we came across your Interlean Competence Profiling Facility: it is very useful! Please could you send me full details on how we can be profiled and how we can use the facility with our existing suppliers!

Regards

Andy Larter,  
Mitchell Cotts Transmissions

**Figure 21 Expressed interest in CPM received from Mitchell Cotts Transmissions**

This expressed interest provides an indication of the perceived usefulness of the methodology. To prove its real usefulness and direct contribution to the performance of engineering SMEs with objective quantitative data would require a larger experiment over a significant period of time. Authors such as Clegg et al (1997) as well as Pyka and Küppers (2002) argue that the real success of innovative systems and methodologies depends on complex set of interacting organisational and social forces that are difficult to change thus, making the technological and organisational outcomes difficult to predict. Therefore, the various case studies described in this research mainly provide evidence of



its perceived usefulness through the acceptance of the real application of the methodology and less through the direct impact it has on engineering SMEs. Evidence of the perceived usefulness have been demonstrated in this research by:

- comments made by key experts and users (e.g. *Figure 21*)
- structured assessment exercise (see paragraph 5.2.2)

In the following two paragraphs a summary of the AWM and NDI cases accompanied by user assessment is provided. A summary and update of the methodology developed and implemented for MAS-WM is provided in section 5.4.

### 5.2.1 Advantage West Midlands (AWM)

AWM is the regional development agency for the West Midlands. AWM was interested in CPM as a tool for supporting the region's supply base of manufactured parts for the tracked transport (rail) industry. After an investigation of the future market potential for rolling stock in West Midlands (AWM, 2002), AWM identified global sourcing as a major threat to regional suppliers. Although the majority of rolling stock supplied to the UK market is produced domestically, the majority of the required equipment is imported. Most of the major manufacturers, such as Siemens of Germany and Bombardier of Canada, import equipment to the UK either as completed units or as major sub-assemblies or components. Siemens, for example, manufacture over 95% of its rolling stock in continental Europe. This concentration of major international manufacturers in the UK has created worries, as the effects in import/export ratios may put at risk the UK supply base.



However, significant opportunities were also identified for SMEs in the West Midlands. The analysis concluded that around 50 companies represent the core capability for the industry with a further potential supply base of approximately 600 companies (AWM, 2002). Although not very actively, it was identified that OEMs were still seeking additional suitable suppliers for particular sub-systems. In response to this opportunity, the promotion of supply consortia was recommended to develop competences and capabilities that would be attractive to OEMs.

### User Assessment

Realising that CPM could perform a key role within this strategy, the author approached key individuals such as Dr M. J. Moore, advisor to AWM, and Mr B. Gregson, AWM supply chain advisor, and demonstrated the methodology. The case of development and manufacture of passenger carriage toilet modules was examined. This was a case identified by Advantage West Midlands (AWM, 2002) as an example of a real opportunity. In *Figure 22* the toilet module which the demonstration was based on is shown.

For the purpose of this example, the following manufacturing processes had been identified:

1. Bending of sheet metal for the formation of parts such as the main case and the door
2. Cutting of sheet metal for the production of parts such as floor and ceiling
3. Vacuum forming for the production of plastic parts of the assembly such as the wash basin
4. Painting of the metal parts of the assembly



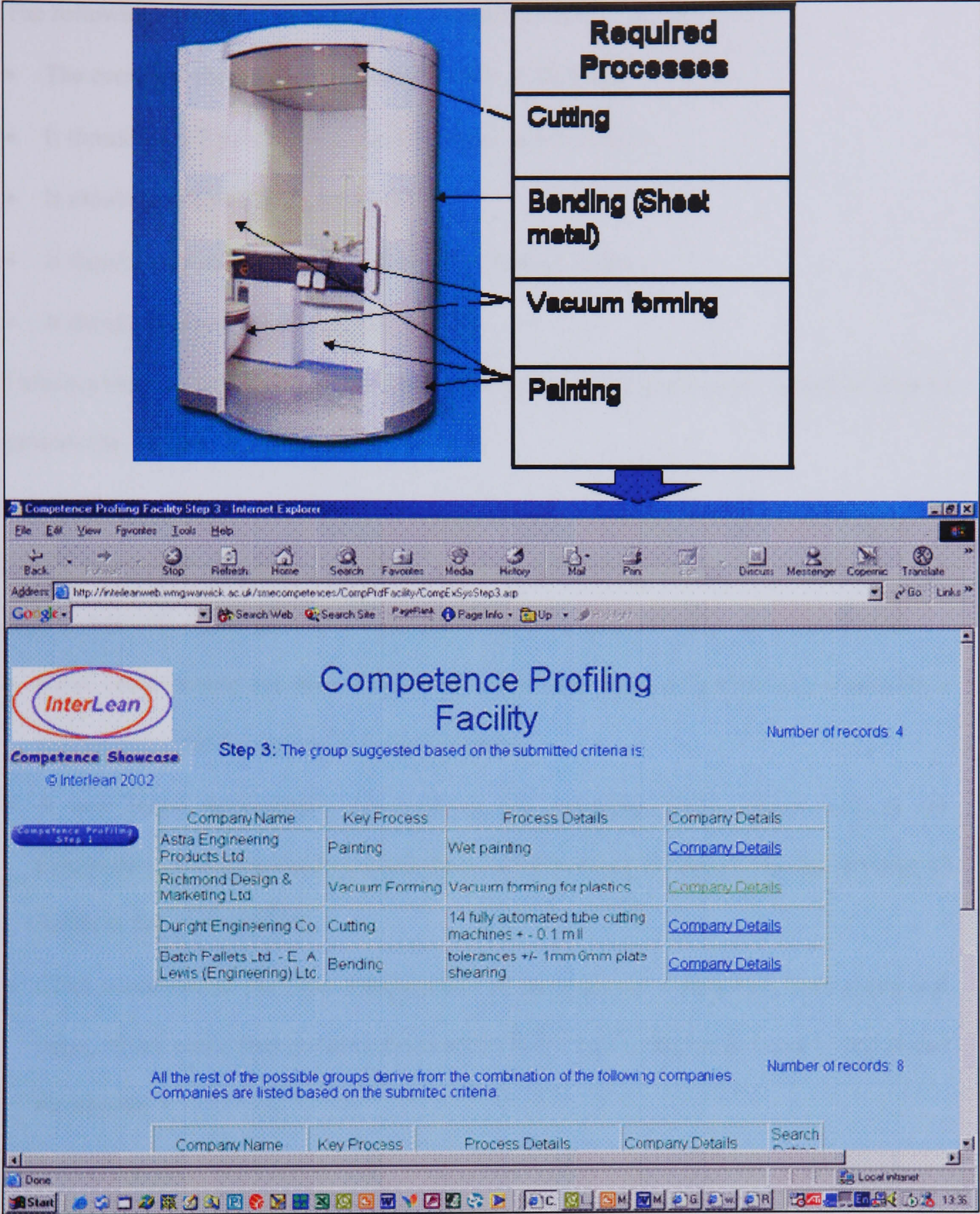


Figure 22 Utilising the Competence Profiling Facility for the tracked transport industry



The following prerequisites were also taken into account:

- The company should comply with ISO9001 or ISO9002
- It should have 2 years experience minimum in the process
- It should be located in the Midlands
- It should have an annual turnover of more than £1 million
- It should have more than 100 employees

Utilising the Competence Profiling Facility, a group of companies was identified able to provide the required competences (*Figure 22*).

AWM recognised the direct link that CPM had with their strategy for promoting SME supply consortia. The impact that CPM could have was claimed to be mainly threefold:

- CPM could enable the identification of SMEs interested in partnering to provide a flexible response for key module requirements
- A web based demonstrator for building and engaging SME clusters such as the Competence Profiling Facility could be an effective way for promoting the abilities of SMEs to the global OEMs
- CPM could reveal the core competences of the regional companies, both small and large, which could then be demonstrated to OEMs and consultants overseas and tested for interest

This and other expressed interests from other key sectors in the West Midlands region, such as aerospace, had significant effect on the evolution of the CPM. Through this interest it became clear that a new and improved competence profile was required capable



to address the extensive needs of the region. An attempt to fulfil these needs is discussed in paragraph 5.3 (The West Midlands Collaborative Commerce Marketplace (WMCCM)).

### 5.2.2 The Northern Defence Industries (NDI)

The Northern Defence Industries (NDI) Ltd is a non-profit making business services company that has developed and established a program of marketing and business development support. Although not an engineering company itself, NDI's views and beliefs about the engineering SME sector have a particular importance as it supports and represents over 200 engineering, manufacturing and specialist service companies in the North of England with the overwhelming majority consisting of engineering SMEs. Its operational focus is the defence and aerospace industry, which represents the source of business opportunities with which NDI matches the supply chain capability of member companies. Its two key operations are to:

- identify 'clusters of companies' to provide integrated work packages and assemblies
- provide information regarding key abilities of member companies according to the customer's request

To this end NDI was interested in CPM as a tool for facilitating the process of identifying and matching the abilities of its member companies in response to prime defence contractors' requests. Its existing method of identifying and matching the skills and capabilities of its member companies heavily relies upon the knowledge and familiarity that NDI employees have with the competences of each member company. No structured methodology was followed in capturing, storing, searching and matching the key abilities



of the member companies. In addition, prime defence contractors, such as Thales and United Defense, often requested detailed and structured information about the key capabilities of NDI's member companies. To handle such requests NDI relies on profiling forms provided by prime contractors on a case-by-case basis. It is usually the situation that NDI profiles the same companies more than once, thus wasting resources and time. Therefore, there was a need for a single common form that would be able to provide appropriate structured information regarding the abilities of the member companies.

### User Assessment

After a series of contacts with the NDI operations manager Mr Gary Scot, the author was invited to demonstrate the CPM. A real case was examined. NDI had received a request by United Defence to identify a potential set of suppliers that would be able to develop and manufacture the MK45 Naval Gun system (*Figure 23*).

The demonstration was focused on the development and manufacture of the gun shield.

The following required manufacturing processes had been identified:

1. Press-work for the formation of the main case and doors of the shield. Due to the need for weather and ballistic protection, aluminium was identified to be the appropriate material to be used.
2. Arc welding for joining operations such as joining door hinges and latches.
3. Injection moulding for the production of plastic parts of the assembly such as door handles.
4. Painting of the metal body of the assembly.



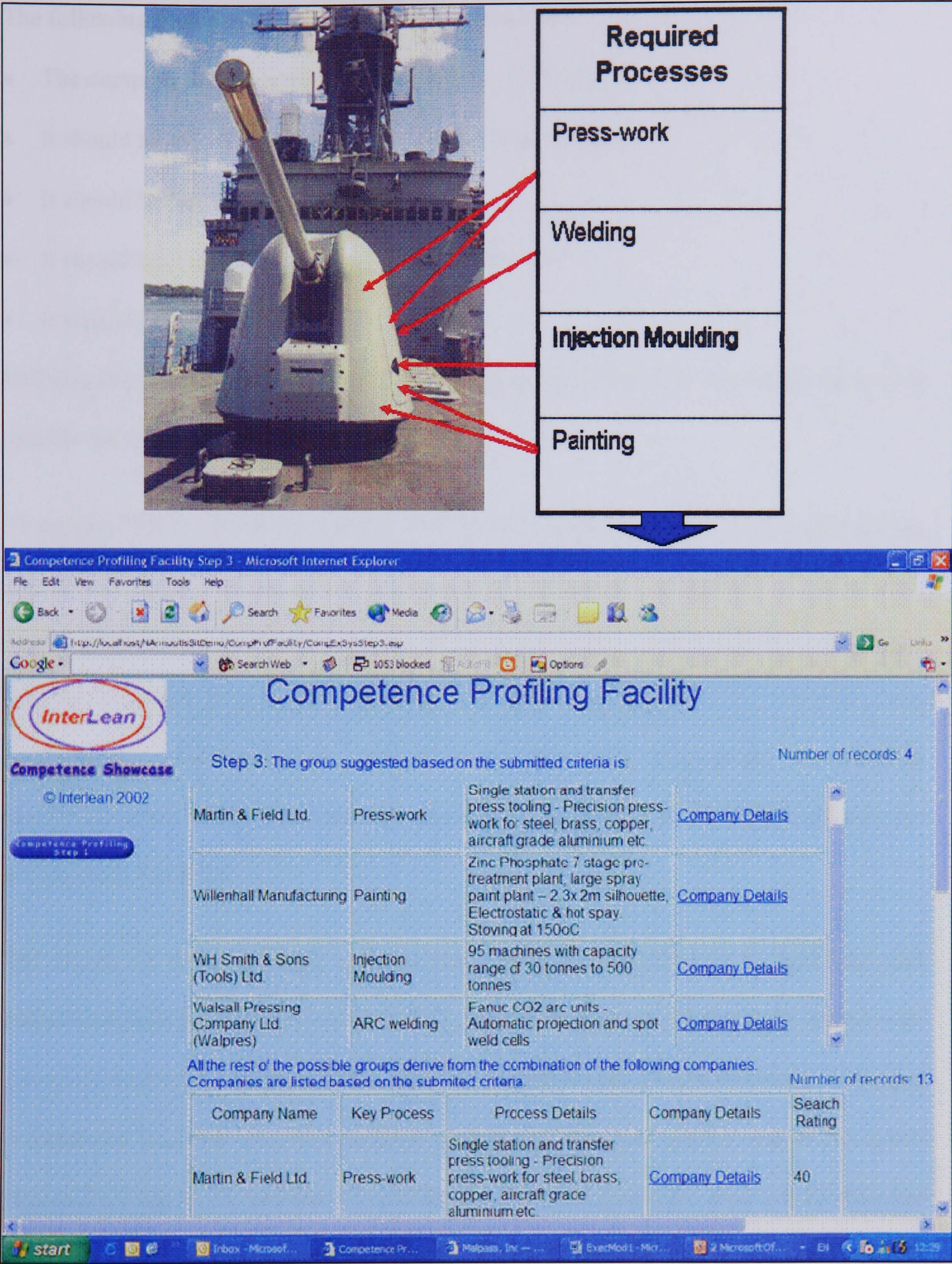


Figure 23 Utilising the Competence Profiling Facility for the defence industry



The following prerequisites were also taken into account:

- The company should comply with ISO9001 or ISO9002
- It should have 2 years experience minimum in the process
- It should be located in the Midlands
- It should have an annual turnover of more than 1 M
- It should have more than 100 employees

Utilising the Competence Profiling Facility, a group of companies was identified able to provide the required competences (*Figure 23*).

To capture NDI's view of the value of the CPM, the 'Competence Profiling Methodology Assessment Form' was developed (*Appendix 5*). The form was designed to assess the degree of perceived usefulness in light of the requirements (see *3.3 Requirements*) and benefits identified at the Autocle@ar and Autolean 3 projects (see *5.1 Benefits of the methodology*). The operations manager, Mr Gary Scot, responsible for supplier identification and cluster formulation, completed it. The results of this assessment exercise are shown in *Table 11*.

The results of the assessment indicate that NDI perceives CPM as a significant and valuable methodology. CPM was rated from medium to high usefulness in all criteria with six out of nine being scored with the highest usefulness rate. The methodology was rated in statement 5 (*Table 11*) with medium usefulness. This was mainly due to the lower interest NDI has in its members diversification. NDI has a specific focus on defence and aerospace in the North East region. However, it was recognised that the methodology was able to support the application of SME competences to new fields and



**Table 11 NDI’s perception of the usefulness of the Competence Profiling Methodology (0 = non, 1 = low, 2 = medium, 3 = high)**

Statement	Score
1. Allowing access to information about an engineering company’s abilities by potential local, national, and international customers	3
2. Considering engineering SMEs for partnership in complex multi-partner projects	3
3. Enabling buyers to electronically search, compare, and match new alternative sources of supply	3
4. Enabling buyers to identify a suitable supplier or group of suppliers by their key abilities	3
5. Providing engineering SMEs with the ability to apply their competences in fields or locations that may be more profitable	2
6. Providing the ability to map the skills and capabilities of a region/sector	3
7. Speeding up the process of selecting suppliers/partners	3
8. Reducing uncertainty in selecting suppliers	2
9. Ease of use of its associate system	2

locations. It was claimed that the methodology could assist NDI members to apply their competences to the diverse defence sectors such as naval and aerospace. In addition, it was stressed that a nationwide application of the methodology could increase significantly the usefulness of the methodology in this respect. What was very important for NDI, was the fact that the methodology has the ability to map competences and identifying gaps of skills or capabilities within the various supply networks.

Regarding ‘reducing uncertainty in selecting suppliers’ (statement 8 in *Table 11*), the methodology was rated with medium usefulness. It was indicated that a mechanism for ensuring that information is always up-to-date was needed. However, it was admitted that CPM provides a mechanism for ensuring structured search, comparison and increased validity of information. Therefore, CPM increases significantly trust and confidence



between trading parties in electronic environments as opposed to other means of selecting suppliers such as looking on company websites.

In respect of the ‘ease of use of its associate system’ (statement 9 in *Table 11*), the methodology was also rated with medium usefulness. It was stated that the Competence Profiling Facility (CPF) lacked a data entry facility which would simplify the process of capturing and storing competences. Nevertheless, as a facility for finding suppliers and matching competences, it was admitted to be simple to use and unique in its capabilities.

All nine statements were found to be very important for NDI and in line with its strategy for the collaboration and promotion of the abilities of its member companies. Further contacts the author had with this organisation led to an agreement for a new Competence Profiling application. This new development aspires to improve the usefulness of the methodology based on the feedback received. A new system is under development that will also enable the on-line capturing and updating of competences of NDI members. This new system aspires to meet the specific requirements of the defence industry, a technology driven sector focused on demanding and rigorous quality standards.

### 5.3 *The West Midlands Collaborative Commerce Marketplace (WMCCM)*

Further to the wide interest and acceptance of the ideas incorporated in competence profiling, new funding has been secured by the Warwick Manufacturing Group, University of Warwick, to develop a regional collaborative e-commerce platform for engineering and manufacturing SMEs, the West Midlands Collaborative Commerce Marketplace. CPM is a core element, the rest of the functionality is structured to support it.



The WMCCM (at [www.wmccm.co.uk](http://www.wmccm.co.uk)) has received over two million euros of European Regional Development funding and has been in operation for over two years. The system has over 2000 registered SMEs, over 200 of which are actively using the platform to (Bal and Armoutis, 2005):

1. Tell the world about what they can do
2. Access new tenders and business opportunities
3. Find suitable partners to help address the requirements of higher value added work
4. Use on-line collaboration tools to reduce operating costs

### 5.3.1 WMCCM Functionality

Key functional elements of WMCCM include:

- Competence profiling and company search capabilities.
- Access to higher value added type tenders sourced from the Official Journal of the European Communities (OJEC).
- Partnership formation capability, driven by the needs of a particular tender, or from a clean start.
- Project collaboration capability. It provides functionality for enabling collaboration on engineering design projects such as sharing and exchanging project files, simple project management, and knowledge management.
- Marketplace capability for generating and responding to RFIs and RFQs as well as running simple auctions and bazaars for items such as surplus goods and unused machinery.



- Purchasing aggregation by providing links to the catalogues of approved suppliers and service providers to WMCCM.
- Clustering capability which allows companies with commonality in location, expertise, or market to have a common look, feel and set of information services.
- External links to a number of relevant marketplaces such as Supply-On, Exostar, and First Index.
- Catalogue capability for SMEs wishing to make available standardised products.

Such functionality empowers SMEs to establish and maintain partnerships on their own with minimal need for intervention of other parties. It could be argued that competence profiling by being a key part of the WMCCM, supports the ‘free market’ principle, where as described by Sloman and Sutcliffe (2004: p64) “individual producers and consumers are free to make their own economic decisions”. CPM is made available via the Internet to business users who can freely and independently make decisions as to whom their partners may be and support and co-ordinate these partnerships during their lifecycle. Authors such as Bruun and Mefford (2004) and Piszczalski (2000) are among others that have advocated the ‘freedom’ that the Internet can provide to the business world by arguing that it enables sharing of information, providing variety and independent decision making.

Approaches that are dependant on direct interventions by third parties, such as the Yorkshire Virtual Enterprise Network (VEN) and Northern Defence Industries (NDI) model, benefit by the presence of a governance structures that undertake many of the tasks involved in setting and running a partnership. Tasks involved may be from searching for appropriate partners to more awkward ones such as handling any potential conflicts



among partners. For example, the VEN ([www.ve-net.org](http://www.ve-net.org)) depends to a significant degree on the human intervention of a ‘business architect’ who identifies possible tenders, constructs the partnership from the registered companies (who are charged for registration), helps them bid for the tender, monitors member performance and manages the project. However, such an approach limits the liberal thinking and decision-making offered in free markets, which as argued by Samuelson and Nordhaus (2005: p725) “...have proved to be the most fertile soil for innovation and technological change”, a “central factor” in economic growth.

The VEN model, which has received a lot of publicity recently, is an example of the current best practice intervention model. A key weakness of this model is the difficulty in scaling up the support so as to make a significant economic difference. It may score a few high profile wins, but will probably never reach regional economic significance without the use of an uneconomic level of resources.

### 5.3.2 Adjustments to CPM

The WMCCM project commenced in June 2002 and the system development stage was successfully completed and officially launched in January 2004. The author had many interactions with, and provided consultation to the WMCCM project team including system integrator Syntegra. Further details of these interactions can be found in *Appendix 6*.



Based on the feedback provided from the WMCCM workshops as well as the experience and lessons gained from the Autocle@r and Autolean 3 projects, a few changes have been made to CPM. These changes are mainly related to the system:

- Modifications and enhancements to facilitate further ‘soft issues’ and commercial consideration. For instance, in stage two of the ‘partnership search’, the option of selecting companies which are able to provide more than one of the required processes is emphasised by showing all the ‘matching processes’ available in each company (*Figure 25*). This enhancement is based on the assumption that partnerships with fewer member companies would have reduced risks, for instance, cultural incompatibilities and logistical costs compared to partnerships with more member companies.
- Changes have been made to improve functionality as well as interface look and feel. For instance, the list of manufacturing processes in the partnership search has been replaced by an expandable hierarchy of processes (*Figure 24*). The long non-expandable list of processes makes it more difficult for users to see available options and find what they need. Research has shown that expandable hierarchies are more efficient as they result in fewer errors to reach the target (Kurniawan et al., 2002). In addition, in stage two of the partnership search companies are grouped based on the selected processes and displayed separately. Clicking the appropriate link the user can identify the companies available for a particular process. In the example of *Figure 25* companies providing ‘injection moulding’ are displayed by clicking the ‘injection moulding’ button at the top of the page.



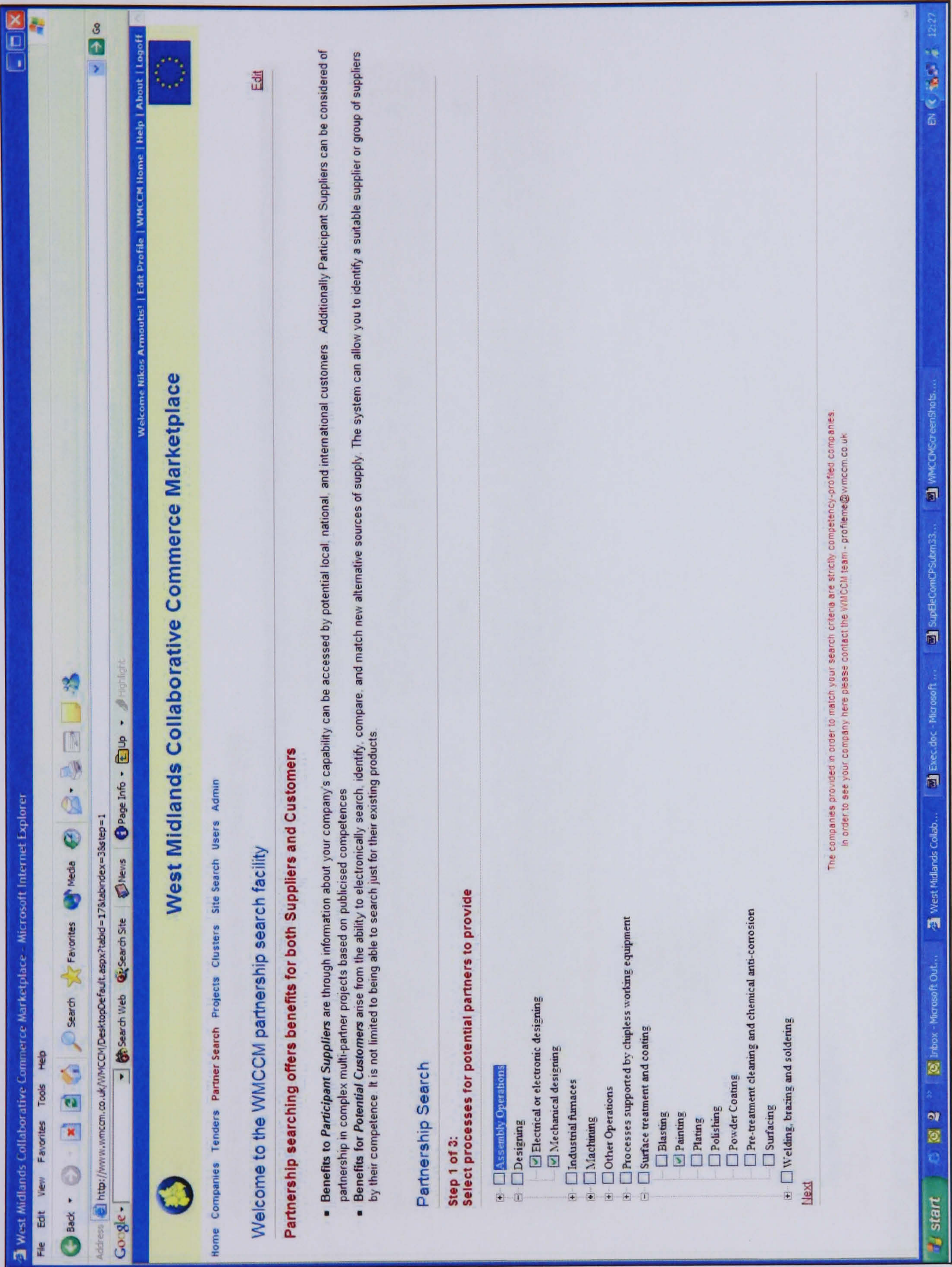


Figure 24 Hierarchy of manufacturing processes in WMCCM stage 1 partnership search



West Midlands Collaborative Commerce Marketplace - Microsoft Internet Explorer

FileEditViewFavoritesToolsHelp

Back

Forward

Stop

Search

Favorites

Media

Print

Home

Go

Addresshttp://www.wmccm.co.uk/WMCCM/DesktopDefault.aspx?tabid=17&tabindex=3&step=2&grouping=1

Google

Search Web

Search Site

News

Page Info

Up

Highlight

Partnership Search

Step 2 of 3:

Select possible partners and scoring criteria

Electrical or electronic designingMechanical designingInjection MouldingPainting

Companies supplying Injection Moulding

Company Name ^

Matching Processes

Processes Details

European Plastic Mouldings Ltd ✓  
01948 663090  
Unit 1, Civic Green Waymills Industrial Estate, Whitchurch, Shropshire SY13 4TT

Injection Moulding

Key Process:  
Injection Moulding  
Plastic Injection Moulding - Insert Moulding  
Ranging from polypropain to nylons to polycarbonate Machinery: Boy 50M, Stubbe 55 tn, Negri Bossi 25 tn

☒

Falcon Plastics Co ✓  
01543 876410  
Unit 7 AML Industrial Estate Rugeley Road, Hednesford, Cannock, Staffordshire WS12 5QW

Injection Moulding

Key Process:  
Injection Moulding  
Thermoplastic Injection Moulding: 3 Boy Machines 15 tonnes

☒

Siemens Automotive Systems ✓  
01952 683600  
Halesfield 25, Telford Shropshire TF7 4LP

Injection Moulding (Mechanical designing)

Key Process:  
Injection Moulding  
Lost core injection moulding

☒

WH Smith & Sons (Tools) Ltd ✓  
0121 748 7777  
Water Orton Lane, Minworth, Sutton Coldfield, West Midlands B76 9BG

Injection Moulding (Mechanical designing)

Key Process:  
Injection Moulding  
95 machines with capacity range of 30 tonnes to 500 tonnes

☒

Group companies according to the following sequence of preference:

1. Location

2. Location  
Number of Employees  
Standards  
Markets

Shropshire

Telford

Whitchurch

Staffordshire

Warwickshire

West Midlands

Back

Reset

Next

The companies provided in order to match your search criteria are strictly competence-profiled companies.

West Midlands Collaborative Commerce Marketplace

SuperElecCompSum33...

Eves.doc - Microsoft...

WMCCMScreenshots...

Figure 25 Example of companies and grouping criteria selection in WMCCM stage 2 partnership search



- Additional functions have also been provided to facilitate flexibility and the user's natural sequence of actions. For instance, at the final stage of the partnership search, the user has the ability to change any company in the suggested group with one of the companies provided in the list of ranked alternatives. This can be achieved by clicking the corresponding remove/add links (*Figure 26*). After finalising his/her preference, the user has the ability to initiate communication with the selected group of companies by clicking on the 'contact' link provided. This automatically launches the e-mail client with the appropriate addresses (*Figure 26*). In addition, the partnership search has been integrated with some other functions in the e-marketplace such as the tendering process. In a tender the customer or the 'initiator' of a project proposes a set of required processes. A supplier who accesses the tender then has the ability to be transferred from the description of the tender to the first stage of the partnership search by only clicking the 'team' link (*Figure 27*). At this stage all the recommended processes are automatically selected. The user can then proceed in identifying other project collaborators to undertake a specific project to address the requirements of that tender.

Since the system needs to accommodate a larger population of engineering SMEs, a more powerful and secure system was necessary. For example, with more than 2700 currently registered users the system is likely to exceed the Microsoft Access2002 limit of 255 concurrent users that Competence Profiling Facility is accommodated with. The new system was developed by Syntegra and is based on an SQL 2000 Server database and the Microsoft Portal Starter Kit. The coding of the facility was done in the Microsoft ASP.NET platform.



West Midlands Collaborative Commerce Marketplace - Microsoft Internet Explorer

FileEditViewFavoritesToolsHelp

BackSearchFavoritesMedia

Address bar: http://www.wmccm.co.uk/WMCCM/DesktopDefault.aspx?tabid=17&tabindex=3&step=3

Partnership Search

Step 3 of 3:  
Suggested partners are:

Companies supplying Electrical or electronic designing

Company	Matching Processes	Process Details	
Richmond Design & Marketing Ltd ✓ +44 (0) 24 76635818 Unit 33 Bilton Industrial Estate Humber Avenue, Coventry CV3 1JL	Electrical or electronic designing	Key Process: Electrical or electronic designing Designing and simulation	Remove

Companies supplying Mechanical designing

Company	Matching Processes	Process Details	
Frederick Woolley Ltd ✓ 0121 523 8341 Fam Street Hockley Birmingham B19 2TY	Mechanical designing	Key Process: Mechanical designing Tool designing (EZ CAD)	Remove

Companies supplying Injection Moulding

Company	Matching Processes	Process Details	
Siemens Automotive Systems ✓ 01952 683600 Halesfield 25, Telford Shropshire TF7 4LP	Injection Moulding Mechanical designing	Key Process: Injection Moulding Lost core injection moulding	Remove

Companies supplying Painting

Company	Matching Processes	Process Details	
Advanced Colour Coatings Ltd ✓ +44(0)121 789 6991 Bannerley Rd, Garretts Green, Birmingham B33 0SL	Painting	Key Process: Painting Wet painting of specialised surface finishes	Remove

This list forms only a suggestion of a combined partnership of companies based upon your search criteria

[Back](#) [Reset](#) [Contact](#)

Other potential partners are:

Electrical or electronic designing Mechanical designing Injection Moulding Painting

Companies supplying Injection Moulding

Company	Processes	Process Details	
WH Smith & Sons (Tools) Ltd ✓ 0121 748 7777 Water Orion Lane Minworth, Sutton Coldfield West Midlands B76 9BG	Injection Moulding Mechanical designing	Key Process: Injection Moulding 95 machines with capacity range of 30 tonnes to 500 tonnes	Add
Falcon Plastics Co ✓ 01543 876410 Unit 7, AML Industrial Estate Rugeley Road, Hednesford Cannock, Staffordshire WS12 5QW	Injection Moulding	Key Process: Injection Moulding Thermoplastic Injection Moulding 3 Boy Machines 15 tonnes	Add
European Plastic Mouldings Ltd ✓ 01948 663090 Unit 1, Civic Green Waymills Industrial	Injection Moulding	Key Process: Injection Moulding Plastic Injection Moulding - Insert Moulding Ranging from polypropain to nylons to	Add

Figure 26 Proposed group of companies that could undertake a project and a list of ranked alternative companies

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123



West Midlands Collaborative Commerce Marketplace

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://www.wmccm.co.uk/WMC/Default.aspx?tabindex=2&tabid=12

Go

Units

Welcome Nikos Anagnostis! | Edit Profile | WMCCM Home | Help | About | Logout

West Midlands Collaborative Commerce Marketplace

Home Companies Tenders Partner Search Projects Clusters Site Search Users Admin

Subscriptions

Description

New

WMCCM Tenders (RFI / RFQ)

WMCCM Tenders is a source for public and private procurement opportunities within the UK. The site provides easy-to-use Internet access to several bidding opportunities with a facility to submit electronic responses.

Tenders

Filter

Keywords

Status

Matching Tenders

alex's football kit

need footie kit for our women

bmw rally car seats

need a dozen for rally - prem

Cat Search

Welding

Press-work

Machining metal fabricatio

Title attributed to the contract

in the South West area.

Manufacture and Supply of

For OEM manufacturer based in W

Manufacture, supply and in

Title attributed to the contract

poles flags and other associa

Manufacture, test and sup

Supply of high chromium abra

spindle pulverised fuel mills

Mobile phone aerial

Electrical

CNC

Mobile Phone Cover Supply

Supply of Nokia mobile Phone accessories for new model under development

Viewing Tender 'Manufacture, supply and installation of bus information structure' - Microsoft Internet Explorer

Manufacture, supply and installation of bus information structure

Originator: Warwick Manufacturing Group (WMG)

Contact Name: Mark Swift

Contact Phone: 1234

Respond By: 10/10/2003

Summary: Title attributed to the contract by the contracting authority: manufacture, supply and installation of bus information infrastructure (cases, poles flags and other associated infrastructure).

Details:

1. Awarding authority: Strathclyde Passenger Transport, 12 West George Street, UK-B Glasgow G2 1HN, Att: Robert Fieel, Tel.: (01 41) 333 37 88, E-mail: xxx URL: xxx

2. Nature and quantity or value, CPA reference number: CPV: 63221000

3. Estimated date for initiating the award procedures: It is anticipated that tenders will be issued somewhere between April and August 2003 for a contract which will require a phased delivery and installation programme ending in March 2006.

4. Other information: Types of contracting authority: body governed by public law.

Companies who wish to express an interest at this time need only submit a covering letter accompanied with some company literature. Once a contract notice is posted all companies who have expressed an interest will be contacted and advised of the qualifying procedure.

Processes: Installation, Service, Welding, brazing and soldering

Skills: Manufacturing, Service

Locations: Locations, Warwick

Edit Respond Team Close

Status: published

Received from WMCCM Website on 10/07/2003

^ Top of page

Status

Received

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Received

Expired

Published

Received

Received

Published

Local intranet

EN

15/07

Figure 27 Example of a tender in WMCCM



### 5.3.3 Economic Sustainability

A variety of revenue models have been employed by e-marketplace operators. The three main models identified by the European Union's Enterprise Directorate General (Perogianni, 2003) are as follows:

- **Commission fees:** In this model the main source of income is fees that are applied to suppliers (or sellers) according to the value of a concluded contract. The benefit of the commission fees model is that users can have access to on-line facilities free of charge as charges apply only if a deal is concluded. However, there is always risk of participants attempting to avoid fees by establishing direct relationships with partners, after a few initial contracts, and not referring to the e-marketplace. Examples of e-marketplaces with such a revenue model are atradapro ([www.atradapro.de](http://www.atradapro.de)), BuyAg.com, and AutoTradeCenter ([www.autotradecenter.com](http://www.autotradecenter.com)).
- **Value-independent transaction fees:** With this model income derives mainly by applying fixed fees to participants. For example, standard charges may apply when fixing a contract or publishing a Request For Quotes (RFQ) and ads. Examples of such e-marketplaces are Mascus ([www.mascus.com](http://www.mascus.com)) and TruckMarket.de. Although fixed fees avoid tempting participants to hide the real value of a contract, they may not adequately reflect the use of the marketplace.
- **Membership subscriptions:** This model depends on usually fixed annual or monthly subscriptions that members are charged. Examples of e-marketplaces that adopt this model are: Truck.nl Parts Locator ([www.truckpartslocator.com](http://www.truckpartslocator.com)), TecCom ([www.teccom-eu.net](http://www.teccom-eu.net)), and AutoPartsBazaar.com. Membership subscriptions are technically easier to apply as payment collection does not depend on the use of the marketplace. The key disadvantage of this model is that users are obliged to pay fees



even if they make low use of the marketplace. When considering SMEs, high subscription fees can be a usage barrier.

All these revenue models are mainly focused on charges to suppliers rather than buyers. Solutions such as First Index and Yorkshire Forward’s VEN can charge an SME up to £3000 annual fee (VEN, 2005). These charges are a result of running costs due to labour intensive operations. Examples of various income streams and labour costs incurred by other approaches in comparison with CPM are provided in *Table 12*.

**Table 12 Labour costs and main stream of income of CPM in comparison with other approaches**

	<b>Labour Costs</b>	<b>Main Stream of Income</b>
FirstIndex	<ul style="list-style-type: none"><li>• System development</li><li>• System maintenance</li><li>• Information collection</li><li>• Assisting searching and matching suppliers with buyers</li></ul>	Suppliers
MfgQuote	<ul style="list-style-type: none"><li>• System development</li><li>• System maintenance</li></ul>	Suppliers
VEN	<ul style="list-style-type: none"><li>• Searching and matching suppliers with buyers</li><li>• Member performance monitoring</li><li>• Project management</li><li>• Conflicts handling</li></ul>	Local government and suppliers
CPM	<ul style="list-style-type: none"><li>• Information collection</li><li>• System maintenance</li></ul>	Local government and third party services

Being a method of helping SMEs to access and exploit e-commerce, CPM can be seen as a part of regional infrastructure that links SMEs with the e-commerce superhighway in the same way as do roads, rail and air infrastructure, allowing the region to interact and trade with the outside world. The provision of broadband is sometimes seen as achieving this, however the author believes that broadband by itself is like a highway passing through the region, no good to the region’s business unless there are some junctions to access it.



CPM needs to avoid high costs. The collection and validation of information with the CPM may be considered to be a costly activity as it involves visiting SME premises and conducting interviews. However, being a governmental non-for-profit initiative, the costs of collecting information are covered by the local government and hence not conveyed to SMEs in the form of fees, which may also include profits.

After the development stage, CPM does not require any substantial human intervention. Users can search and identify partners without the need of any ‘business architect’ as in VEN, discussed in paragraph 5.3.1 *WMCCM Functionality*. Therefore, the only costs involved are limited to the maintenance of the system.

It is proposed that the WMCC marketplace will be available to engineering SMEs at no cost provided that they will be competence profiled. The cost for the development of the infrastructure is the responsibility of local government. The running costs can be funded through charging third party service and product suppliers for access to the marketplace. It is estimated that over 2500 SMEs would be registered in the WMCCM. Considering that the average West Midlands SME has a turnover of around £1 million, the size of the prospective marketplace could then potentially be over £2500 million. This can be an attractive target for many sellers, especially as many large blue chip organisations do not have appropriate sales channels into this type of market. Thus, engineering SMEs can benefit by the CPM and WMCCM’s toolset without paying any fees.



The focus of the project is now on competence profiling companies. Over 200 engineering SMEs have already been profiled and the constantly positive feedback obtained is encouraging. The likelihood of success is even higher considering the establishment of links between WMCCM and electronic tenders from the Official Journal of the European Communities (OJEC) and First Index. With more than 1500 tenders currently available on-line and over 40,000 having passed through the system, profiled companies have an increased potential to engage in new projects through WMCCM.

#### *5.4 Expertise profiling: Finding sources of advice for engineering SMEs*

Expertise profiling refers to the application of a variation of the Competence Profiling Methodology (CPM) for the Manufacturing Advisory Service in the West Midlands (MAS-WM). The methodology supports the process of finding sources of advice for Small-Medium Engineering Enterprises (engineering SMEs).

##### 5.4.1 Background

In February 2001 the UK government announced with its White Paper ‘Opportunity for All in a Word of Change’ (DTI-DfEE, 2001) the development of the ‘Manufacturing Advisory Service’ (MAS). The main objective of the service was to provide small and medium sized manufacturers with hands on help with new manufacturing technology and best practice. Regional Centres for Manufacturing Excellence (RCMEs) were established by Regional Development Agencies with the support of DTI. MAS advisors based in RCMEs provide free information and advice to all UK manufacturers. SMEs, in particular, are provided with diagnostic field services in collaboration with specialist sources of expertise within each region.



Launched in July 2002, MAS in the West Midlands (MAS-WM) is one of the RCMEs. A key intention of the service is to link SMEs with the science and innovation base of the region. When an enquiry from an SME arises, the appropriate specialist source of expertise (or Centre of Expertise in Manufacturing) is searched for and recommended. The existing approach of finding these specialist sources of advice relies mainly on advisors and Industrial Liaison Officers (ILOs). They make recommendations as to what source would be more appropriate based on their individual contacts and knowledge of the region's sources of expertise. However, this approach is very much dependant on an inconsistent personal judgement and a limited human memory. Considering only the higher education sector in the West Midlands, to give a sense of the complication of this decision, there are 12 institutes each with many departments, research groups, initiatives, and individuals able to provide a large variety of specialised expertise. The question was then 'what process should MAS-WM follow to ensure that the best possible expertise providers are recommended?'.

#### 5.4.2 Expertise Profiling Methodology (EPM)

A methodology was developed that addressed the identified requirements of expertise identification, structure, and search. Although the methodology was intended to be applied for all types of expertise provider, it was mainly tested for higher education institutes, such as universities and colleges.

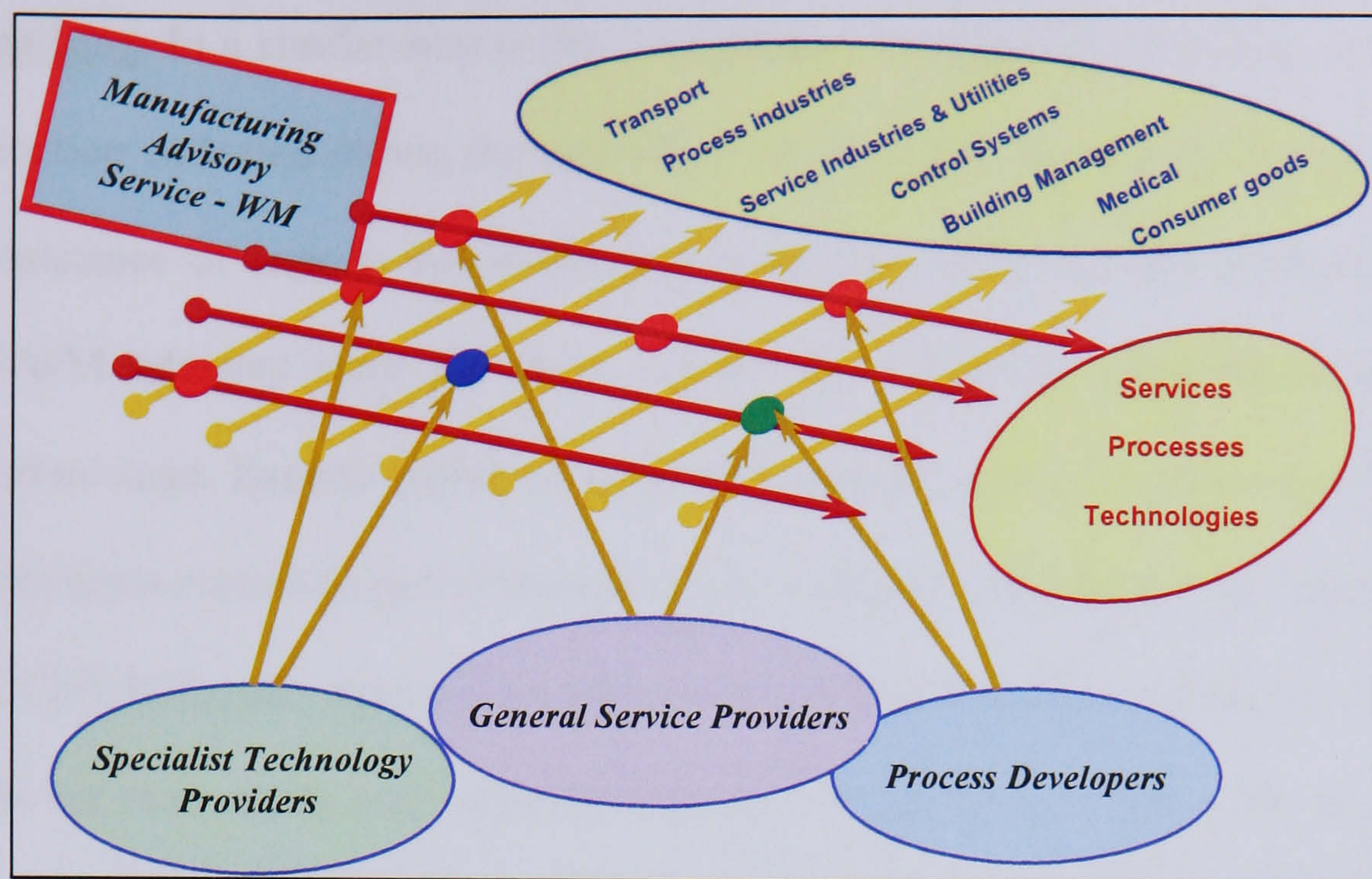
The methodology, analogous to Competence Profiling Methodology, consists of four main stages:



- Expertise data collection. Expertise profiling is utilised to collect competence related information. The term ‘expertise’ was utilised instead of ‘competence’ to denote the two different applications. ‘Competence’ was utilised to capture the key skills and capabilities of the engineering SMEs whereas ‘expertise’ focuses on capturing the key skills and capabilities of specialist service providers. Being always associated with people’s specialized knowledge, skills and practice (Tonomura, 2002), the term ‘expertise’ denotes a focus on an individual’s expertise. MAS is an organisation which key purpose is to provide advice. Since this advice is provided by individuals, individuals ‘expertise’ have a primary role.

A new profiling form, the ‘Associate Profile Form’ (APF) (*Appendix 7*), was designed around the concepts on the competence definition (*4 Competence Profiling Methodology*). The APF was a result of several iterations. A discussion on the changes made is available at (*Appendix 8*). The APF was designed to serve the fundamental purpose of the MAS. That was to enable SME manufacturers to have appropriate access to advice and guidance in 'best practice' processes and new technologies (DTI-DfEE, 2001). In response to this emphasis on processes and technologies, a classification of the expertises offered by expertise providers in the West Midlands was created. The graphical representation of the network of providers, the 'matrix of services for the MAS-WM', is shown in *Figure 28*.





**Figure 28 The MAS-WM matrix for business processes, technologies and general services**

The horizontal lines represent the various services offered by the providers. Three types of services were identified:

- Business processes such as project management, product introduction, and supply chain management.
- Technologies such as CAD/CAE/CAM/CIM, information, and environmental technologies.
- General services such as accounting, accreditation, and facilities management.

The vertical lines represent the DTI type of classification of industrial sectors. Nodes in the matrix of services represent service providers. A node indicates the specialised service offered and the sector served by the provider. A single provider may be represented by more than one nodes.



- Normalising. In a similar way to the Competence Profiling Methodology, some of the information collected during the interviews required subjective judgement. Therefore, the assistance of experts was considered essential within the normalisation process. MAS-WM advisors were the main experts that normalise information during the collection stage. Experts' opinions were also required during the process of matching requests from manufacturers with appropriate expertise. This process was outsourced to the CONTACT, an organisation that assists higher education institutes in finding outlets for their skills and expertise among industry in the region. Its people have gained a good understanding of regional abilities through their well established relationships with the HEIs of the region. Direct involvement of such an organisation could assist in gaining consent from regional expertise providers which would ease the implementation and transformation of the new MAS-WM processes.
- Information searching. At this stage information on expertise is stored in the 'Expertise Database'. The Expertise Database is a web-based system developed to allow storing, updating and searching of the collected competence (or expertise) information. Due to a confidentiality agreement between service providers and the MAS-WM, the system is not open to the public Internet. It has been used exclusively by the MAS-WM and its partner CONTACT. More details of the system can be found in submission 3 (paragraph 3.4 *Expertise information searching and job requesting*).
- Job request. In finding the appropriate expertise provider, potential organisations identified in the database are requested to respond to a job request. In addition to the conventional means of contact, such as telephone, fax, post, and e-mail, the Expertise Database supports SMS messaging. SMS messaging can be used as the vehicle to cost



effective mobile business (m-business). Corporate implementation of wireless technology attracts increased interest, as it is believed that there is great potential for financial benefit (Ewalt, 2002). Limitations in bandwidth networks and lack of co-operation between wireless service providers on common standards have caused speculation among authors, such as Ewalt (2002) and Dekleva (2004), as to whether m-business is an economy driver or a “mess”. However, it is well understood that significant benefits can be achieved as m-business provides the opportunity to eliminate the barriers of time and location, enabling business to be conducted anywhere at any time. Evidence from early adopters has indicated that significant efficiencies and cost savings can be gained. For instance, by applying m-business technologies General Motors has achieved savings of \$1 million at one of its assembly plants by enabling forklift operators to receive work instructions wherever they are (Collett, 2003).

### 5.4.3 Benefits of the methodology

The suggested approach alters significantly the way that advisors deal with expertise providers. Their approach of dealing with few providers that they are familiar with, appears to have similarities with the traditional Japanese and Just-In-Time (JIT) philosophy. This philosophy is supported by closer and long term relationships with limited number of suppliers. Authors such as Womack et al (1990), Christopher (1998) and, Slack et al (2001), have for long now identified such benefits as:

- Reliable flow of delivery of services
- Joint venture type of partnerships instead of adversarial relationships which require time consuming negotiations
- Open and trustworthy relationships with the selected suppliers/providers



- Sharing of information and joint problem solving
- Business is customer driven

With the EPM, however, the same benefits are achieved when dealing with a large number of providers (suppliers). Large number of providers means more options and larger diversity of expertise available to MAS-WM and its customers, manufacturing SMEs. To achieve that there is no need for long term joint venture type of partnerships. Instead, availability of specific specialists when a requirement arises for a short period of time is needed. A more dynamic and flexible type of relationship fits better within this context. The concept of ‘virtual organisation’ where a team of organisations form a short term partnership or collaboration to address a specific requirement is more appropriate. Within the scope of the MAS-WM this partnership consists of the MAS-WM and the expertise provider(s). ICT is vital for the realisation of a successful virtual organisation (Preiss et al., 1996; Christopher, 1998; Introna, 2001)). The ICT offered with EPM facilitates this concept.

Other identified practical implications of EPM are in summary as follows:

- The application of the EPM addresses the issue of fairness of job allocation. Based on an SME enquiry, advisors have the ability to search the Expertise Database for the associates with the appropriate expertise. Associates can be searched for based on the information submitted on their Associate Profile Form (APF). Job allocation is based on a transparent and explicit approach which is able to capture and trace appropriate expertise available in the region.
- In contrast with the simple ‘telephone directory’ type of information provided by many institutions, the EPM has the ability to capture the competence of the expertise



providers. Following the definition of competence, a profile form was developed that captures the competences of the expertise providers in detail and in a structured manner.

- The development of the Expertise Database provided the MAS-WM with the opportunity to search for and identify appropriate expertise providers in response to a help request. It offers also the opportunity to store providers' performance ratings after completing a job. Quick identification of suitable providers with specialised abilities can be achieved by utilising ICT tools such as SMS.
- A simple and straightforward approach was developed. With the assistance of MAS-WM and CONTACT advisors, expertise providers complete their forms in a simple MS Word document format. The users of the Expertise Database receive the electronic form via e-mail and by using their browser access the Expertise Database where they copy and paste the information. When a request for a particular expertise arises, the user accesses and searches the Expertise Database again through a web browser.

#### 5.4.4 Issues during implementation

Delays in registering their services on behalf of the region's institutes were observed at the initial stages of the MAS-WM operation. The collection of 18 profiles within the first three months of the implementation, 12 less than the stated target, indicated a significant delay in the real use of the methodology. Some of the technical issues need addressing are described in *Appendix 9*. However, the introduction of the MAS and, in particular, the implementation of the MAS-WM processes altered the existing operational process. Such changes usually result in upheavals, beyond the straightforward technical ones, as the balance of power changes across the society or the organisation where a change occurs



(Holmes, 2001). Such social upheavals were created with the introduction of the MAS-WM and the Expertise Database. For example:

- The introduction of the MAS-WM operation may be considered as setting particular jobs at risk. In particular, Industrial Liaison Officers (ILOs) and other individuals that act as liaison between institutes and industry could feel that they become less important. The operation of the MAS-WM and its Expertise Database has the ability to reach groups and individuals with the appropriate expertise within institutes without the need of intermediates such as ILOs. This type of potential conflict of interest usually creates politics against legitimate power and rational actions (Holmes, 2001) which may lead to large delays or even failure of development and implementation of new processes or applications such as the EPM.
- The use of new technological tools may cause fear to some organisations due to lack of skills. Authors, such as Holmes (2001), Clegg et al (1997), and Boddy (1996), call attention to the worries that new IT systems may create in individuals with limited IT skills. The Expertise Database has created such concerns not only to associates but also to the MAS-WM advisors and the CONTACT team. For instance, the involvement of SMS during the interactions with the associates had created concerns to individuals who are not familiar or comfortable with this particular type of technology. The fear of being excluded had been expressed.

Other key reasons for the significant delays on the full implementation of the EPM have been identified and discussed in *Appendix 9*, where some further developments on expertise profiling are provided, as well as in submission 3 (paragraph 4.6 *Issues raised during implementation*).



Although the number of collected profiles did not meet the stated target and therefore the methodology was of limited use, the acceptance for implementing the EPM within the scope of the MAS-WM indicates that the concepts introduced were well received. However, a well populated and maintained expertise database is required to make the EPM fully operational and to allow the MAS-WM to benefit from its use. Achieving that certainly involves a substantial effort not only from providers who offer the information, but also from the MAS-WM and its partner CONTACT that collect and store this information. Considering the benefits gained though, this effort can be regarded as highly rewarding.



## 6. Discussion

Prosperity, economic growth, and wealth generation have always been key objectives for most good governments. The significant role that the small business sector has within the socioeconomic setting has generated increasing interest (and concern!). Small Medium Enterprises (SMEs) in the UK account for 99.8% of businesses, about 65% of non-government employment, and 45% of turnover (SBS, 2002). This engineering doctorate concentrates on this sector with a particular focus on manufacturing and engineering companies and the issues addressed can be regarded of national importance.

Recognising first that SMEs face significant challenges and that their survival is under severe threat, collaboration facilitated by ICT was identified and suggested as the route for improving their competitive position. The issues addressed in this research assist in enabling effective collaboration among SMEs. These issues derive from some false, the author believes, assumptions made by many of the existing e-business based solutions. Assumptions such as:

- Engineering SMEs should be identified and classified according to their end products
- Engineering SMEs could be assisted towards trading on-line by utilising the catalogue capability in e-commerce for standard products
- There is a standard evolution path for SMEs to adopt e-business
- E-business = broadband



In the following sections the author evaluates and analyses the work undertaken during the course of this research. This analysis starts by examining the research methodology followed in tackling the identified issues.

### *6.1 Discussion on research methodology*

Case studies were the main research method used in this research. This research method lends itself more to the ‘phenomenological paradigm’, which as Bonoma (1985) argues precision in measurement, data integrity, and replicability is compromised for currency, contextual richness, validity and industry relevance. This research may have also compromised reliability over validity. For example, there is nothing to suggest that if another researcher was to repeat this research attempting to answer the same research question (provided in paragraph 2 *Research methodology*) he/she would achieve the same result, the development of the Competence Profiling Methodology. The developed methodology is significantly based on subjective judgements the author made while observing and interacting with SMEs. However, the implementation and testing of the CPM in various projects (section 5 *Implementation and testing*) reinforces the reliability of the testing results, as similar observations and interpretation have been made repeatedly by various individuals. Over 300 companies with a significant variety of competences have participated through the various projects, either by completing the competence profiling questionnaire or by testing the CPM and the relevant system. Testing in other industrially validated researches appears to be less comprehensive. For instance the work conducted by Akarte et al (2001) on their web-based supplier selection methodology was focused only on casting suppliers. One case study was conducted in India which included a demonstration of the developed methodology to 50 engineers and managers.



The phenomenological approach followed in this research is less objective than a positivistic one (Blaxter et al., 2001). This research did not collect data and evidence of a numeric kind, which is generally regarded more precise and unbiased (Bonoma, 1985). However, it allowed capturing and analysing complex concepts (Hussey and Hussey, 1997). The concept of competence certainly may be considered as such. The author would argue that the findings and conclusions are richer partly because they were captured in their natural location. This allowed a more realistic approach and a closer observation of the phenomena. For instance, the ability of engineering SMEs to manufacture a wide variety of products was perceived by having the opportunity to look at real examples of products during the visits. In addition, the direct interactions the author had with over 80 engineering SMEs gave him the ability to obtain in depth understanding of their key characteristics. Through the MAS-WM project the author had the opportunity to interact and appreciate the key characteristics of the expertise providers. These providers were mainly groups within the Higher Education Institutes in the West Midlands. Sixteen manufacturing related research groups were profiled from 8 out of the 12 Higher Education Institutes in the region. This mixed experience allowed the author to identify key commonalities as well as differences between engineering SMEs and research groups. Commonalities include:

- One person's views and values often influence all the aspects of the company's/group's activities. This person is the owner-managing director in the case of an SME and the founder-director in the case of research group.
- Finding customers/project partners is usually a result of networking.
- They usually offer their services in a variety of industrial sectors.
- They operate in an environment of intense competition. Engineering SMEs compete with other engineering companies in many cases with larger size from



them either regionally, nationally, or internationally. Similarly research groups compete with other groups from any location.

- Due to intense competition, they are often secretive. SMEs are often secretive about commercial information and their specialised abilities, and research groups about their not formally published novel ideas.
- They are required to demonstrate high standards of responsiveness.

Differences identified are:

- SMEs are often reliant on a small number of customers. Although there are cases where research groups are also reliant on small group of partners, they are in general more flexible. They may change their partners depending on the subject and the requirements of the project they undertake.
- Financial resources are limited in SMEs. Their purpose is to be profitable and to maximise their profit margins. Research groups usually obtain financial resources through various sources of funding, such as the Government and the European Commission. However, being non-profit organisations, these resources are for a very specific use, usually described in the relevant project proposal.
- Although both engineering SMEs and research groups are very often highly specialised, research groups are more often able to differentiate themselves from others.

Although positive responses were received while testing the ideas discussed in this research in the North East region of the UK (5.2.2 *The Northern Defence Industries (NDI)*), this research is mainly limited to the West Midlands region. The majority of projects undertaken were specifically for this region. If more regions had been considered, greater validity as well as reliability in this research would have been



achieved. However, it would not be wrong to argue that due to the general commonality in political, legal, financial, and social structures among the different regions in UK, the results of this research have great relevance to other regions.

## 6.2 *Theories and practices*

To develop and implement the required methodologies, this research has been based on theories and practices mainly from three subject areas:

- Supplier identification
- Supplier appraisal
- Organisational competence

Theories and practice from areas such as knowledge management and business organisation could also be included within the scope of this research. For instance, techniques that assist knowledge management across the supply chain may be utilised. In particular, audio and visual techniques, as described in paragraph 7.1.1 *Enhancements to the CPM*, may be used to present more effectively the competences of an enterprise. Additionally, methodologies from the business organisation field and in particular Business Process Re-engineering (BPR) seek to understand businesses in terms of key processes (Doumeingts and Browne, 1997). Utilising process modelling techniques such as the Integrated DEFinition (IDEF), they aim to offer principles for business organisation which maximise the effectiveness of key processes. Similar modelling techniques may be used to express more effectively the abilities of an engineering SME.

In addition, the organisational learning perspective could also be incorporated. In assisting engineering companies to improve their prospects, emphasis has been placed



on their competences. This is a perspective usually associated with a resource-based view which concentrates on firm-specific capabilities and assets (Collis and Montgomery, 1995; Lewis and Gregory, 1996; Mills et al., 2002). However, as authors such as Hitt et al (2000) and Mothe and Quelin (1998) suggest, abilities can also be gained through learning. Organisational learning can be achieved through various methods, such as (Rheen, 1995):

- Skill acquisition; cultivating new capabilities in either teams or individuals.
- Experimentation; trying out new ideas.
- Continuous improvement; trying to master each step in a process before moving on to the next.
- Boundary spanning; pursuing information from sources outside the organisation such as benchmarking against competitors.

Although explicit consideration of organisational learning in this respect has not been conducted, the methodologies proposed in this work could support an interpretation from the organisational learning perspective. First, collaboration is usually perceived as a method of learning. It may be regarded as a ‘boundary spanning’ type of learning as well as a method of encouraging ‘skill acquisition’ and ‘experimentation’. Hitt et al (2000) argue that collaborations provide an opportunity not only to combine the resources of the partners, but also to learn and develop their skills. Their survey verified that one of the important criteria for partner selection is the opportunity provided to learn special skills from partners (see *Table 5* at paragraph 3.2.2 *Partner/supplier appraisal*).

In addition, a direct learning opportunity is provided by the MAS-WM in subjects relevant to engineering SMEs. Expertise Profiling Methodology (EPM) could be



considered as a method that allows access to organisations that can provide, in addition to expert advice in a particular issue, the training associated with it.

This combination of learning and matching of complimentary resources that the Competence Profiling Methodology (CPM) facilitates indicate that the resource based perspective could co-exist with the organisational learning perspective. This is a view also supported by Hitt et al (2000). The question that then arises is ‘when is learning preferable to matching competences?’ or ‘where the boundaries are between combining competences and learning?’ This is a decision that companies need to make by examining each individual situation. In such decisions, factors such as the time and resources required, as well as the short and/or long term benefits need to be considered.

### 6.3 *Meeting the research objectives*

The overall aim and objectives of this research have been described in section 1.2 (*Research aim and objectives*). The extent and the means to which these objectives have been met are discussed in the following paragraphs.

#### 6.3.1 Inhibitors preventing engineering SMEs e-business adoption

The investigation into the inhibitors that prevent engineering SMEs successfully adopting e-business identified six key inhibitors (section 3 *Engineering SMEs and E-Business*). In summary these are as follows:

1. Trust and confidence issues deter customers from dealing on-line with engineering suppliers.
2. E-commerce is mainly focused on standardised products. However, many engineering SMEs provide highly customised products or ‘one-offs’ and



- therefore the well-developed catalogue capability in e-commerce is of limited value to them.
3. On-line directories generally classify engineering companies according to their end products. However based on their skills and capabilities, engineering SMEs are able to provide a wide range of customised products and therefore classifying them by their end-products at an instant in time may be unnecessarily misleading and restrictive.
  4. Traditional e-business uptake models such as Cisco's (2001b), and Earl's (2000) are too generic and require substantial resources and technical skills that many SMEs do not have.
  5. Attempting to make comparisons among different engineering SMEs based on information provided by their private websites is a tricky task. This is mainly because of three reasons:
    - a. The type of information provided on websites varies among the various companies. This inconsistency makes direct comparison between companies difficult.
    - b. Often there is no structured information in what an engineering SME can do.
    - c. Information is often inaccurate and outdated and therefore not valid.
  6. Although e-marketplaces may offer the validity and consistency required as well as information on the abilities of an engineering SME, they often require high registration fees. Since most –marketplaces are of the vertical (industry focussed) type, and the average West Midlands SME sells into three different markets, this usually means three registration fees have to be paid.



Other inhibitors that hinder e-business uptake among SMEs have been indicated in early reports (DTI, 2000; DTI, 2001) such as: security, lack of basic ICT skills, speed of the Internet, and incompatibilities between systems. However, recent developments have significantly reduced many of these barriers. For instance, developments in encryption technology, virus scanning software, and ‘firewalls’ have allowed the UK government to claim that security issues are now a myth (DTI, 2003b). Similarly, the availability of quality and range of training is continually expanding, 69% of businesses that identify gaps in ICT skills now use training to address them (DTI, 2004a). Internet speed is also improving with the introduction of ‘broadband’ technology. Evidence indicates that broadband penetration is accelerating. The proportion of businesses using xDSL has risen from 13% to 24% within a year (DTI, 2004a). In addition, new technologies and standards such as ‘XML’ and ‘.NET’ contribute significantly in overcoming incompatibility issues.

In contrast, the inhibitors identified in this research are proving to be persistent and largely unresolved. Trust and confidence issues are recognised by various researchers to be core obstacles that need to be addressed effectively (PriceWaterhouseCoopers, 2002a; Perogianni, 2003; Afsarmanesh, 2005). In addition, ‘unsuitability of products’ is the most common reason given by UK businesses for not adopting existing on-line techniques (DTI, 2004b), something that this research calls attention to for engineering SMEs. Regarding private websites, research by the DTI (2003c) has indicated that more than 12% of small businesses have discontinued their websites as they had limited use by customers and no significant direct business benefits were experienced. Finally, high set up and running costs are recognised as a key barrier and discouraging factor towards adopting e-business techniques and technologies (DTI, 2004b).



### 6.3.2 Examination of methods of identifying on-line suppliers and partners

In this research, various methods of identifying on-line suppliers have been examined.

In summary, key learning points of this examination are as follows:

- On-line identification of suppliers or partners has received less research attention and hence there is a need for methodical investigation and development of a structured solution that enables the assessment, selection and matching of complementary competences to form virtual organisations.
- An assumption is often made that SMEs have in place mechanisms to collect hard data such as lead times and defect items.
- The success of collaboration is dependant not only on the obvious and quantifiable issues such as availability of a machine with certain type of capacity. It is also dependant on soft, non-measurable, and unquantifiable issues such as organisational culture.
- To enable matching of complimentary competences as well as capturing and bringing to light possible innovative and unique engineering processes, a solution needs to be unbounded by a particular engineering process or sector.
- On-line directories generally provide only activity area and contact information for the listed companies.
- Many solutions have high fees, lack simplicity and quickness in use and thus hinder SME acceptability.

Although this examination of methods is limited to the engineering sector, it enabled the author to concentrate on a sector that is often considered to have one of the most intensive uses of advanced ICT and e-business (EDG, 2004). This focus also enabled



the author to analyse, compare and contrast methods such as on-line directories on both national (e.g. FirstIndex) and international (e.g. MgfQuote) scales (see 3.2.1 *Partner/supplier identification*). In addition, methods have been examined which gave the author an insight into supplier and partner selection such as the ‘Virtual Enterprise Network’ (VEN) introduced by Lau and Wong (2001) and the ‘Cyber Stamping’ by Tang et al (2004) (see 3.2.2 *Partner/supplier appraisal*). Although the main focus was on on-line methods, conventional methods have also been examined, such as yellow pages and the ‘Proficiency Matrix’. The benefits were twofold:

- Strengths and weaknesses of such practices were identified which could be delivered or avoided when designing the new methodology. For example, examining the appraisal procedure (Barker and Steele, 1994) suggested by the Chartered Institute of Purchasing and Supply (CIPS), it was recognised that visiting a supplier’s premises is very important in increasing the validity of the collected competence information and therefore reduce the trust and confidence barrier when suppliers are to be selected
- Assessment of the effectiveness of the methodologies, methods, and tools developed during this research were made through their comparison with ones used in industry or suggested by other researchers. Example of such a comparison is the one between the Proficiency Matrix and the Associate Profile Form in paragraph 4.4 *The ‘Proficiency Matrix’ and the Associate Profile Form (APF)* in Submission 3.



### 6.3.3 Proposition of a mechanism to facilitate e-business and enable collaboration

The Competence Profiling Methodology (CPM) has been proposed as a mechanism to facilitate e-business and enable collaboration. CPM would enable competence data collection, normalisation, on-line search, and matching. It would facilitate e-business for engineering SMEs by focusing on what the real abilities of SMEs are rather than their end products. Collaboration would be enabled by matching competences and suggesting a group of companies to undertake complex projects. The key assumptions that CPM is based upon and thus may be questioned to test for weaknesses in the methodology are:

1. SMEs can/will provide the information required
2. Competence information is updated and validated after profiling
3. There is an expert whose knowledge and experience is appropriate to normalise the information
4. The user of the facility:
  - a. has a need for quality supplier information
  - b. can identify the competences required to manufacture a system
  - c. has determined a purchasing strategy approach
5. Trust between business partners is dependant on competences of a company

In more detail:

1. There is always the risk of companies refusing to provide information. The reasons usually stated by companies are (Hussey and Hussey, 1997; Blaxter et al., 2001):



- Time; managers are busy with activities related to their core responsibilities and it is very difficult to draw their attention from these. Unless they are convinced that direct benefit is gained, they will not allocate any time to any other activity.
- The distraction of other employees.
- The breaking of confidentiality agreements; managers are very careful of the information they provide. They worry about the consequences of accidentally breaking any confidentiality agreements either within the company or between the company and its partners.
- The disclosure of sensitive information: In a highly competitive environment companies usually fear the disclosure of information which is considered important for competitive advantage.

A quote from a manufacturing manager obtained during interviews sums this all up: “We mainly use the Internet to find out information about our customers and competitors. We do not want to tell them too much about ourselves!”

Although these reasons may appear to be sensible, the benefits gained by the participating companies can make them trivial. CPM benefits companies directly by providing them the opportunity to win new, enhanced, value added business. Authors such as Prahalad and Ramaswamy (2000), Preiss et al (1996) Kanter (1994), and Dodgson (1991) recognise the need for companies to escape their sceptical viewpoint in order to enjoy the benefits of collaboration. Vertical or horizontal collaboration can generate mutual benefits that far outweigh the benefits of secrecy.



2. The methodology described includes visiting companies for the collection of competence information and then manual storage and maintenance of the data, a labour intensive and hence costly procedure. In addition, there is no formal mechanism for updating the competence information in the facility. Changes to the competence status of a company may occur. For instance, a company may acquire new competences by employing new people or new machinery, or a key person may leave a company. It is assumed that information is updated on companies' request by contacting the administrator of the facility. However, a formal mechanism would ensure that information from all companies, even those that receive fewer enquires from potential customers, remains up-to-date. The whole process of collection, storage and maintenance of competence information may be more effective if participating companies have the ability to submit and maintain their information on-line. Companies may then be encouraged to update their information at regular intervals after being prompted by CPM administrators. The major issue that then arises is how the submitted information would be validated?

Maintaining a feedback mechanism similar to the one provided by MfgQuote (see paragraph 3.2.1 and *Figure 8*) or 'eBay', the world's largest personal online trading community ([www.ebay.co.uk](http://www.ebay.co.uk)), may be a solution. Every eBay user, buyer or seller, has a feedback profile made up of comments from other traders. These comments can be positive, negative, or neutral depending on the experience a buyer or seller had. Positive comment is represented by +1 point, negative by -1, and neutral by 0 point. The trading users collect points as well as textual feedback which can then be available to the public. A similar mechanism could maintain and validate the competence information submitted



in competence profiling facility. However, an issue that needs to be considered is whether or not SMEs would have the skills and resources to follow such a fully automated process. In addition, as explained in paragraph 4.2 *Normalising*, the judgement of an expert is unavoidable requirement of the normalisation procedure and therefore visits of experts in company premises may need to take place anyway.

3. The existence of an expert(s) who can normalise the information gathered is a key element of the CPM. Considering that there are degrees or levels of expertise, it is difficult to determine who the expert with the appropriate level of expertise is. The expert should have good knowledge and experience of the field. Specifically, he/she may have characteristics as described by Prof. Turban and Aronson (1998). "Experts can take a problem stated somewhat arbitrarily and convert it to a form that lends itself to a rapid and effective solution... Experts should be able to explain the results, learn new things about the domain, restructure knowledge whenever needed, break rules whenever necessary (that is know the exceptions to the rules), and determine whether their expertise is relevant. Finally, as experts approach the boundaries of their knowledge, they gradually become less proficient at solving problems, but can still develop reasonable solutions. All these activities must be done efficiently (quickly and at low cost) and effectively (with high-quality results)". It is apparent from Turban's and Aronson's description that the selection of an expert is a process significantly based on subjective criteria. It is a complex issue which may add subjectivity to the whole approach. However, it is accepted that experts in a field always exist (Waterman, 1985; Turban and Aronson, 1998). In the case of the CPM, experts were both industrialists, such



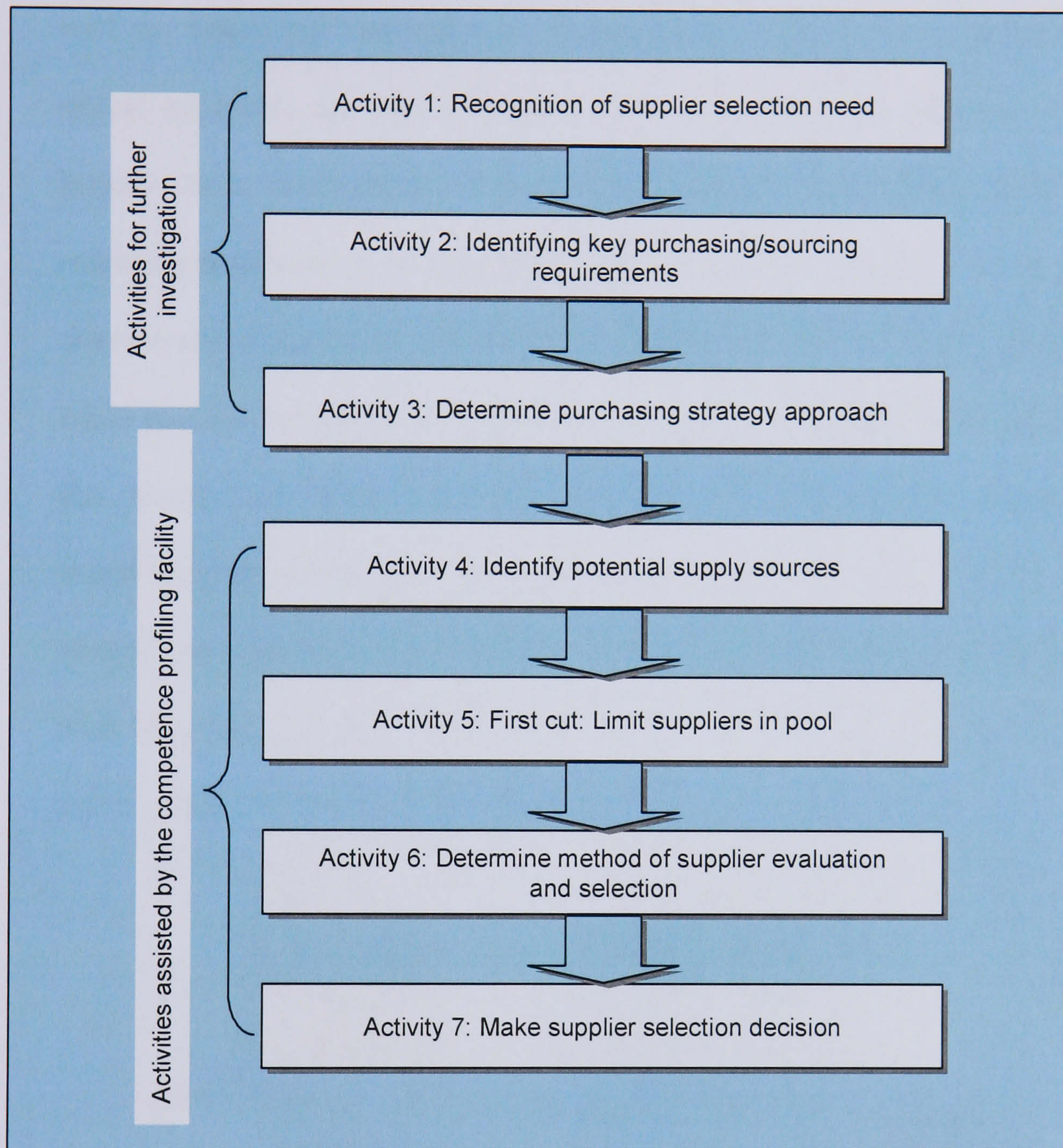
as Michael Szcziegael with many years of experience in engineering SME processes, and Higher Education Institutes employees, such as the author with knowledge and understanding in competence profiling. Such a combination of industrialists with academics is considered to be vital and very beneficial while promoting innovation and best practice (DTI, 2002a).

4. Contrary to the majority of the solutions currently offered, the Competence Profiling Facility addresses several of the activities in the supplier selection process as this suggested by Monczka et al (1998). As shown in *Figure 29*, it assists the last four steps of the process. Potential supply sources can be identified (activity 4), suppliers are selected according to the processes required (limiting, activity 5), a methodology for appraising suppliers based on competences and a set of criteria is provided (activity 6), and finally a group of companies able to undertake a project is proposed (activity 7) based on information provided.

The facility, however, assumes that the first three activities in the process have been executed. In order to provide a more comprehensive solution, the facility would need to be extended to include the other three activities. Many proposed methods are available in the literature to address these activities. For instance, in the initial stages of a new product development process a full specification for the product may not exist. Therefore, the processes required to produce the product may not have been determined. Adopting a method to identify and suggest an optimum set of operations based on a product concept could be introduced. This method would eventually identify sourcing requirements (activity 2) and match them with manufacturing processes. The House of



Quality as suggested by Hauser and Clausing (1988) could be used for this purpose. Furthermore, details of how this can be done as well as other suggestions of how to address and incorporate other supplier selection activities are provided in *Submission 2* (section 6 Discussion).



**Figure 29 Supplier selection activities assisted by the Competence Profiling Facility and the potential for further investigation**

5. Building trust between business partners is a multifaceted and complex task. Authors such as Afsarmanesh (2005) indicate the multi-dimensional character of trust within a virtual organisation environment. Afsarmanesh identifies four key components of trust (*Figure 30*). Competence profiling address two of Assarmanesh components, namely “capability” and “self-reference”, by



providing validated information of a company’s skills, resources and culture. Therefore, the assumption that trust is dependant on company’s competences is validated by this model. However, as indicated by Afsarmanesh, “goodwill” indicated by elements such as moral responsibility and positive intentions as well as “behaviour” indicated by factors such as open communication and ethical approach, are also important. The CPM could be extended to also include these components of trust. For example, a structured process of recording performance of companies and feedback of customers and partners after the end of a project, such as the one proposed in point 2 of this paragraph, could provide the means of capturing information on goodwill and behaviour that would assist further on trust alleviation. Such a recording mechanism would keep an extensive performance history of each company, from the outset of their participation to the collaborative environment. Hence, it would comply with the view that trust is past performance related requiring an extensive period of time to be built (Harris et al., 2000).

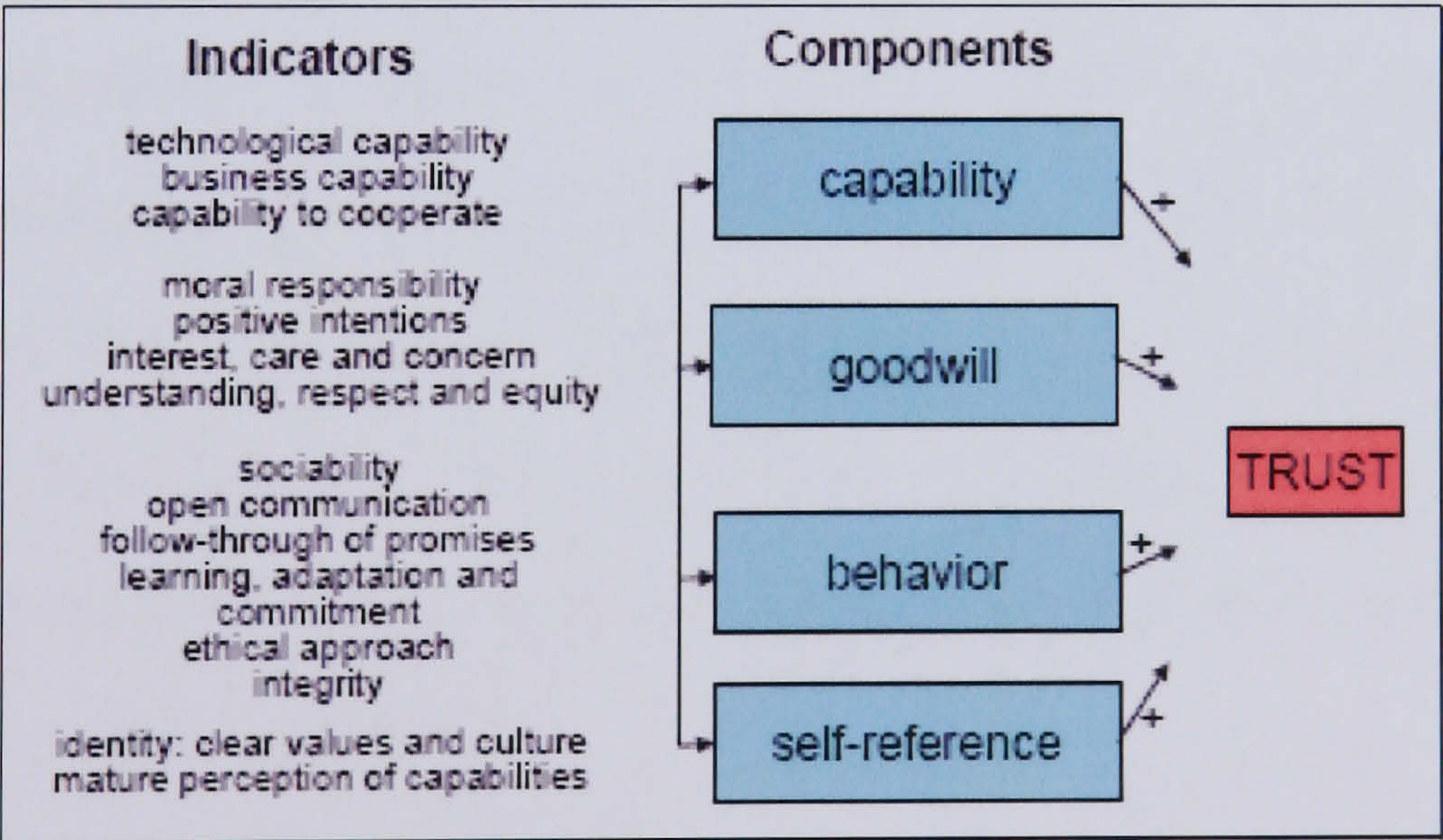


Figure 30 Components of trust as identified by Afsarmanesh (2005)



### 6.3.4 Development of appropriate and innovative e-business based methodologies and tools

The Competence Profiling Methodology has been developed to fulfil requirements such as the need to highlight the real abilities of engineering SMEs and to assist towards identifying and selecting confidently competent suppliers or partners in view of forming virtual organisations (paragraph 3.3 *Requirements*).

Methods and tools developed during this research include:

1. The Competence Profiling Questionnaire
2. The on-line Competence Profiling Facility which enables the formation of Virtual Organisations (VOs)
3. The Associate Profile Form
4. The Expertise Database

The methodology deals with many of the problems that existing methods and practices have. Most importantly, it focuses on competences instead of end products and leverages collaboration. It enables lower cost as well as quicker build of virtual organisation by establishing a pool of SMEs that can be matched to dynamically create collaborative supply networks. The vision of the European ECOLEAD initiative ([www.ecolead.org](http://www.ecolead.org)) provides an example of the contemporary thinking that validates the importance of such a methodology:

“In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations.” ([www.ecolead.org](http://www.ecolead.org))



The methodology though has not fully addressed the issue of ‘subjectivity’. It is still based on subjective judgments from the person that normalises competence information and the user of the Competence Profiling Facility (CPF). However, although subjectivity may be inevitable in any human-based decision making process, the competence definition (chapter 4 *Competence Profiling Methodology (CPM)*) provides a structure for easier judgements, comparisons, and decision making.

### 6.3.5 Field test of the developed methodologies and tools

The author applied the Competence Profiling Methodology (CPM) in five key industrial case studies:

1. Autocle@r project (section 5 - *Implementation and testing*)
2. Autolean 3 project (section 5 - *Implementation and testing*)
3. Manufacturing Advisory Service – West Midlands (MAS-WM) project  
(paragraph 5.4 - *Expertise Profiling: Finding sources of advice for engineering SMEs*)
4. West Midlands Collaborative Commerce Marketplace (WMCCM) (paragraph 5.3 *The West Midlands Collaborative Commerce Marketplace (WMCCM)*)
5. Northern Defence Industries (NDI) (5.2.2 *The Northern Defence Industries (NDI)*)

Through these applications, CPM was tested and problems and difficulties were identified and addressed. For instance, during the Autocle@r project the author identified misunderstanding when interviewees were asked to identify the key people in their business. In many cases interviewees were indicating only individuals at the top managerial level. To eliminate this misunderstanding, interviewees were asked to nominate an individual from each of the following areas:



- Quality
- Production
- Engineering
- Quotation/Project management

These areas are generally recognised as the key areas involved in a bidding process.

The case studies also provided the opportunity for the author to assess the value of the methodology. Several demonstrations were made in front of over 150 engineers, experts and managers during workshops and events such as the ‘e-now’, a Regional IT Association (RITA) event. Of particular merit was the evaluation of CPM in the context of the Institute of Mechanical Engineers (IMECHE) Awards for Manufacturing Excellence conducted by Dr John Garside. Such demonstrations resulted in the acceptance of CPM for application in initiatives such as WMCCM and by organisations such as MAS-WM.

Evidence of the perceived value and usefulness of the CPM has been also demonstrated in this research through an assessment exercise conducted at Northern Defence Industries (see paragraph 5.2.2 *The Northern Defence Industries (NDI)*). The exercise enabled the author to assess in a more structured manner the perceived usefulness of the methodology by measuring its effectiveness based on nine key attributes. One may argue that if such a structured assessment had been applied to all cases, a more unambiguous quantitative indication on the value of the methodology could have been provided. However, the spontaneous and unformatted responses received are also significant evidence of the usefulness of the methodology. They indicate the natural and genuine appreciation of the value of the work conducted in this



research. The originality of such responses is claimed by authors such as Otley and Berry (1994) to be a key benefit of case studies research.

#### 6.4 *Additional lessons learned*

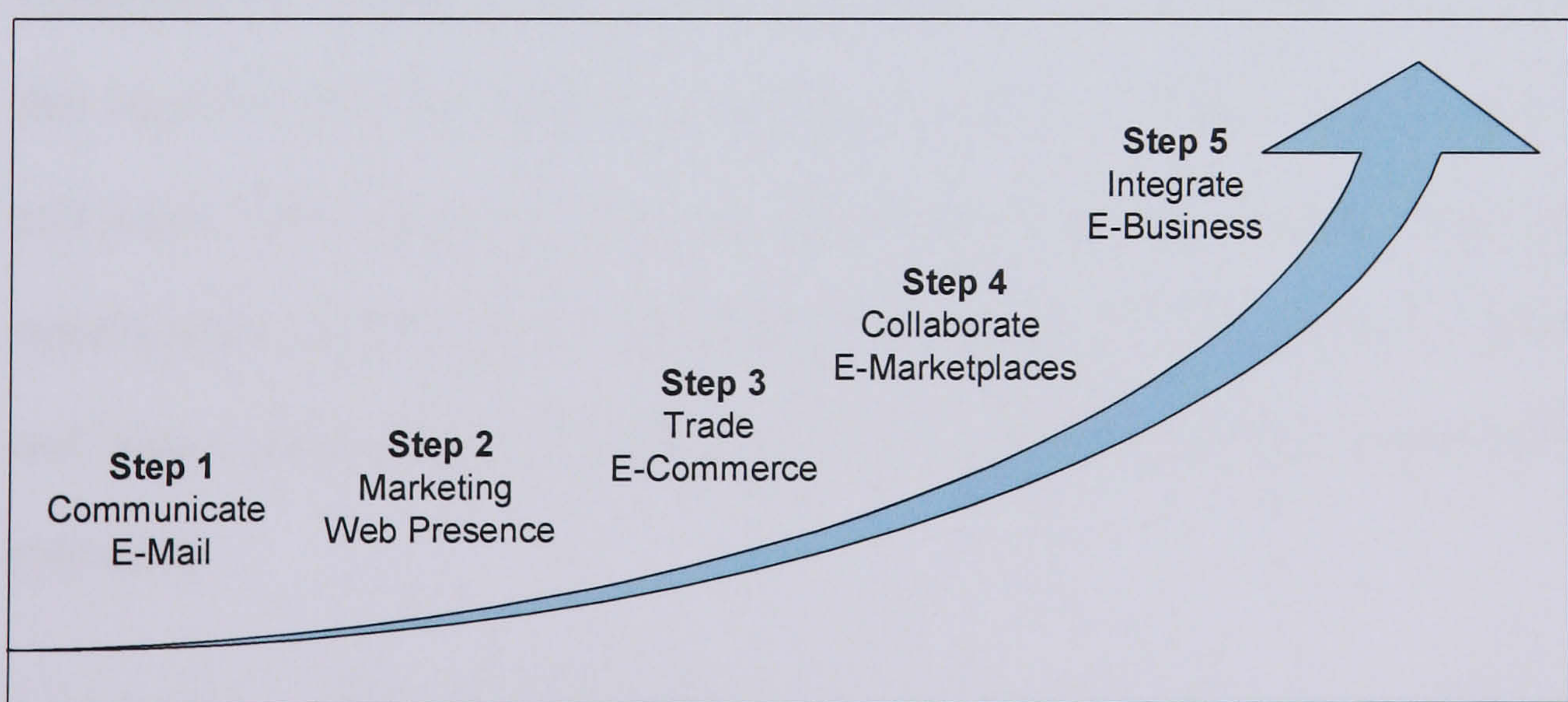
During the course of this engineering doctorate the Research Engineer had the opportunity to acquire knowledge and experience as well as improve his skills and abilities in a broad set of areas. Summaries of these are provided in *Appendix 1*. Two more lessons learned, which the author considers noteworthy are:

- Although top management support is indeed critical for the successful implementation of new processes in an organisation, real consent from the broader community should be treated as equally critical. This community includes all associated individuals at any hierarchical level, either within the organisation or outside it such as partners, suppliers, and customers. Having achieved that, the allocation of real ownership and acceptance of that ownership is also critical. Projects that impact on a wider community are unlikely to be effectively implemented in short time. They cause social changes which call for efforts from all project participants to accommodate. This is a lesson derived from all the projects undertaken. The MAS-WM project, however, made this lesson more direct mainly because of the link the MAS has with the wider manufacturing community. This includes manufacturing related organisations such as SMEs, Higher Education Institutes (HEIs), trade associations, technology institutes, and training centres.
- ‘Timeliness’ has critical importance for the success of a technology implementation. In particular, knowing the stage of ICT sophistication that a sector



or an organisation is experiencing can have significant impact in the level of acceptance of a particular implementation. The Cisco e-business model, adopted also by the Department of Trade and Industry (DTI, 2002b), provided an adequate basis for understanding the development stage that engineering SMEs were at in comparison with larger enterprises. It should be pointed out, however, that the significant infrastructure, operational, commercial, and cultural differences that engineering SMEs have in comparison with larger enterprises, make it difficult to represent e-business evolution for both sectors in a single model. As SMEs move towards the higher stages, the model becomes less representative.

A more appropriate model needs to be sought. The model proposed by Bal and Blanco (2002) is an example of a model that provides a practical interpretation especially for the engineering SME sector (*Figure 31*). The main differences compared with the Cisco model are in stages four and five. In stage four e-commerce is taken one step further by incorporating SMEs into on-line communities where a different number of suppliers and buyers interact in a secure environment. Exchange of information, goods, and resources is facilitated.



**Figure 31 Five steps to e-business profit**

(Source: E-Business Uptake Methodologies for the Engineering SME (Bal and Blanco, 2002))



In stage five, e-business provides customers, governments, suppliers, partners and employees with electronic systems and services to support on a real time basis, internal and external processes, as well as other knowledge based activities. At this stage the concept of virtual organisation is realised to its full extent. Engineering SMEs can enjoy the benefits of collaboration and sharing of any type of resources.

Such a model assists in understanding where a sector or organisation is, where it could move to and therefore making appropriate recommendations. During this research the author has observed these changes taking place, and through the Autocle@r and Autolean 3 projects has moved a number of engineering SMEs through the stages of this model. The majority of them were at the 'communicate' stage, simply exchanging e-mail. A smaller proportion of them were at the 'marketing' stage by posting simple marketing information on a website. As a result of the Autocle@r and Autolean 3 projects, some SMEs are now consolidating their position at the 'trade' and 'collaborate' stages. This is facilitated by the emergence of e-marketplaces such as 'OJEC' ([www.ojec.com](http://www.ojec.com)) on an international scale and the Collaborative Commerce Marketplace in the West Midlands in particular. It is clear that aspects beyond the purely technological, such as cultural, social, economical, and legal, will need much fuller consideration to realise the concept of the virtual organisation. In this respect, the research underway on 'communities of practice' and 'virtual communities' (Collins et al., 2003; Afsarmanesh, 2005) may be of great relevance.



### 6.5 *Innovation summary*

One of the key purposes of this research is to demonstrate innovation in the application of knowledge to the engineering business environment. The applications of ICT facilitated collaboration and the Competence Profiling Methodology (CPM) with a particular focus on engineering SMEs demonstrate this. Focusing on the innovation in these applications, novel features have been introduced to the West Midlands manufacturing community. It should be noted, however, that the novelty claimed is linked to the time they were introduced, as described by the relevant submissions, and not the time this summary was created.

Starting from the idea proposed through the Autocle@r project for ICT assisted collaboration, the key novel feature of the proposed solution was as follows:

1. The idea of competence-profiling was introduced for capturing the competences of an engineering SME and allowing for a basic search to identify suitable groupings of companies to complete a job. It might be used to identify possible suppliers for a new product, or alternative suppliers for an existing product. It would allow the formation of virtual organisations.

Focusing on the application of the CPM to engineering SMEs, three features were identified as novel:

2. The methodology focuses on competences rather than products. In contrast with other web-based identification and appraisal methodologies, it does not concentrate on the existing end products, but on what may be possible. This is based on the



recognition that engineering SMEs are able to manufacture a large variety of products based on their key skills and capabilities. This capability had been provided via the Go4Gain and 2WM portals and it is now available in a more fully developed form in the West Midlands Collaborative Commerce Marketplace ([www.wmccm.co.uk](http://www.wmccm.co.uk)).

3. A working definition for the term competence is introduced which integrates the competence perspectives examined in previous research.
4. The methodology suggests a group of companies to undertake a project. In contrast with other identification and appraising processes, it provides the ability to match competences offered by various companies. Based on these matches and considering hard and soft factors, the Competence Profiling Facility suggests a group of companies that can best meet requirements. This is a key element in forming virtual organisations and an identified need in the European ECOLEAD project.



## 7. Conclusions

The research presented in this document recognises that existing challenges could drive the engineering SME sector towards significant decline with severe effects on the national economy. It identifies that collaboration and e-business have an important role in enabling engineering SMEs to respond to such challenges and undertake higher value work. A new ICT based methodology has been proposed and implemented to support collaboration by enabling reliable identification, comparison, and combination of engineering SMEs within an e-business environment. In summary, the conclusions drawn from this research are as follows:

1. SMEs are required to provide system type solutions to the increased demand for competences by their customers. Collaboration can allow the aggregation of competences. Low cost Internet based collaborative tools are key facilitators.
2. Recognising their real skills and capabilities can be more important than the existing products for engineering companies. Based on existing skills and facilities an engineering SME can manufacture many variants or completely new products for a large variety of market sectors.
3. Existing e-business approaches are strongly consumer and standard product orientated and thus largely inappropriate for engineering SMEs.
4. Competence is a combination of skills and capabilities and is expressed through the ability of a company to change and adapt to new market opportunities.
5. By making competence information publicly available through the public Internet, e-business for engineering SMEs can be enabled.



6. The development and implementation of a unique web-based methodology enables searches for competences as well as generation of partnerships or virtual organisations in response to project requirements.
7. The wider community has a critical role in the success of an implementation and therefore gaining its consent is crucial. Time should be allowed for the appropriate social changes to be made within the broad community affected.

The ideas developed have been implemented and validated within the Autocle@r and Autolean 3 SME development projects and the Manufacturing Advisory Service – West Midlands (MAS-WM). Additional testing and validation is undergoing through initiatives such as the West Midlands Collaborative Commerce Marketplace (WMCCM). Through this research the author was able to progressively develop a broad set of competences. Further work could expand the scope of the solutions developed and validate further the ideas proposed.

### *7.1 Recommendations for further work*

Several opportunities for further work have been identified within the individual submissions. In summary four key areas are proposed for further investigation.

#### **7.1.1 Enhancements to the CPM**

Technological advances will provide the methodology with the potential for further enhancements. For instance, the emergence of web portals which facilitate the process of capturing and searching Intellectual Property (IP) and expertise could enable the integration of the ideas embedded in the Expertise Database with other supporting operations. An example of such a portal is the ‘IPRXchange’ provided by Scientia



Solutions Ltd ([www.scientiasolutions.co.uk](http://www.scientiasolutions.co.uk)). IPRXchange is a gateway which allows business to access and identify opportunities to exploit commercially technology, research expertise, and IP developed by universities. The system enables IP and expertise to be captured and searched through a search engine. Examples of functions offered by IPRXchange ([www.scientiasolutions.co.uk](http://www.scientiasolutions.co.uk)) include:

- Ability to administrate and control access for different type of users
- Allowing users to bookmark and track technology queries, as well as responses
- Forwarding queries to appropriate experts

Although the current focus of application is from the university or technology provider side, the potential for serving the requirements of organisations such as the MAS exists.

In addition, the competence information that the CPM manages is in textual form. More comprehensive ways, however, could be used to capture and display competence information. One of the advantages of the Internet and the WWW is the ability to present visual and audio information. The methodology could make use of this advantage. For example, according to the Chartered Institute of Purchasing and Supply (Barker and Steele, 1994), visiting supplier's premises and observing facilities is an essential part of the supplier appraisal process. Replication of this real situation in the Internet could be made by utilising techniques of presenting panoramic images on the Web that can be panned and zoomed. 'Virtual tours' in a factory could be made. Facilities and equipment as well as typical products could be presented. Links to supporting text and voice-overs for further details on skills and capabilities could be also provided. This technique has been applied at Warwick Manufacturing Group for presenting information about items of heritage at Coventry's heritage website ([www.coventrytour.co.uk](http://www.coventrytour.co.uk), *Figure 32*). The site provides



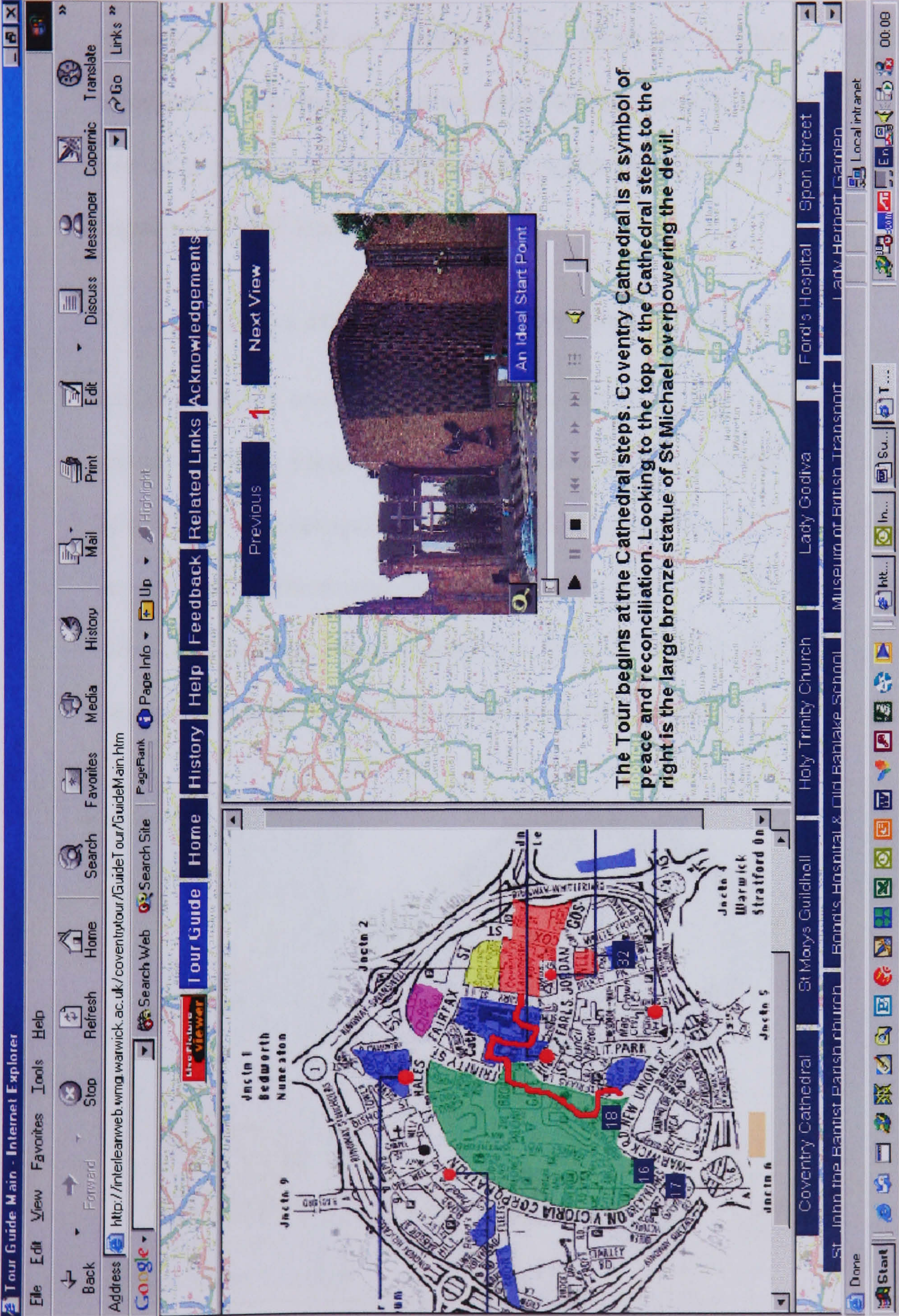


Figure 32 The virtual tour in the Coventry Heritage website



access to information about items of heritage. There are two main ways of accessing the information: either through a guided general tour or by directly clicking on specific items of heritage identified in a window. The virtual tour contains a mixture of photograph panorama, still pictures, narrative, sound and text as well as video. The same institution is also in a process of investigating the application of the same technique in managing engineering SME knowledge assets.

7.1.2 Facilitate other supplier/partner selection activities

An investigation could be made into how other activities in the supplier/partner selection process could be integrated in the CPM. Examples have been provided in paragraph 6.3.3. In addition, an investigation could be made on how decisions on selecting partners would be affected by introducing the option of acquiring new skills and competences through structured learning. Incorporating the ideas introduced in EPM into the CPM would generate a single methodology for competence matching and learning (*Figure 33*).

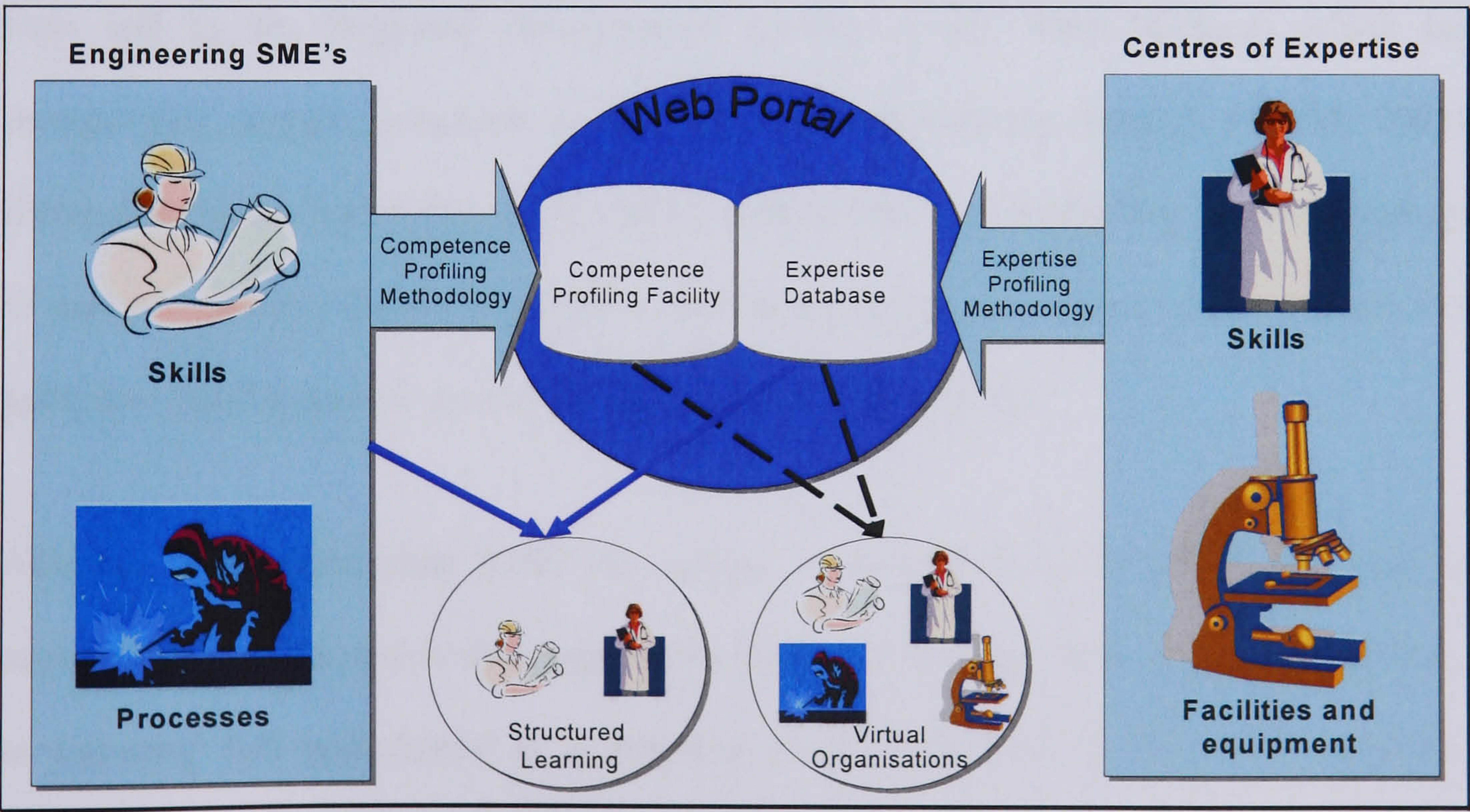


Figure 33 Incorporating EPM into CPM



This new methodology would facilitate:

- a) The process of building new relationships dynamically and creating virtual organisations based on customers' requests
- b) The process of identifying appropriate expertise providers for assisting the process of acquiring new skills required for meeting customer requirements effectively

In addition, EPM could facilitate the resolution of problems that may appear during the establishment of these dynamic partnerships such as tooling and product/process design problems. It would also assist in finding specialised facilities not available in SMEs. A single web portal, which would accommodate variations of both the Competence Profiling Facility and the Expertise Database could facilitate this idea.

### 7.1.3 Integration with clustering strategy

'Cluster' concepts have been seen by analysts such as Prof M Porter as a crucial element in enhancing the UK competitiveness (Porter and Ketels, 2003). Similar emphasis has also been laid by the Regional Development Agency in the West Midlands which has incorporated cluster promotion in the region's manufacturing strategy (AWM, 2003). Defined by Porter and Ketels (2003: p27), clusters are "geographically proximate groups of interconnected companies, suppliers, service providers, and associated institutions in a particular field, linked by commonalities and complementarities".

Although at a conceptual level the notion of clustering conforms to the idea of collaboration introduced in this engineering doctorate, a further investigation could assist in ensuring full compliance at a practical level. The West Midlands Collaborative Commerce Marketplace (WMCCM) has made a first attempt in doing so. Clustering capability is introduced where regional companies with similar or complimentary interests



and needs can facilitate their collaborative activities in a dedicated and secure web space. However, more needs to be done to facilitate the full concept of clustering. For instance, allowing searches and access to regional service and expertise providers as well as partnership searches specialised and dedicated to companies within a cluster would bring the CPM closer to the clustering concept.

#### 7.1.4 Implementation to other sectors and regions

The ideas introduced in this engineering doctorate have been mainly tested in the West Midlands. However, the potential of testing and disseminating these ideas to other regions is open. Individuals from 160 different countries, out of the 192 in total recognised by the United Nations, have already accessed WMCCM. Other regions in the UK and beyond have expressed their interest in implementing the ideas incorporated in competence profiling such as:

- The Institute for Promotion of Small Enterprises (IPSE) in Malta via the Commonwealth Secretariat
- Durham University in the North-East of the UK
- Scientia Solutions in Yorkshire and Humber, UK
- TECOS, the Slovenian Tool and Die Development Centre
- Monash University in Melbourne, Australia

As the concept of collaboration penetrates and becomes more acceptable in economic communities, the potential of further applications of these ideas would expand. A last example of potential application is the one cultivated by the European Framework Programs. One of the main objectives of the Framework Program 6 (FP6) is to develop synergies and enhance complementarities between member nations' research activities.



There are cases where a successful application for FP6 funding pre-requires collaboration among institutions and companies of more than one member nation. For instance, a condition for applying for ‘Integrated Projects’ is that there are a minimum three participants from three different member states (EC, 2002b). A cross-European application of a variation of the Competence Profiling Methodology could facilitate the process of finding partners and establishing effective consortia to undertake specialised projects.

Finally, the work undertaken has provided the author with extensive and valuable knowledge and experience. It has enabled him to understand and appreciate the substantial beneficial impact that collaboration can have not only at an organisational level, but also at a personal one, too. Working closely with many teams and mixing skills with numerous individuals was a key catalyst in improving his personal abilities as well as in building significant relationships and contacts. The skills gained and the relationships established can generate many future opportunities.

Going back to the quote from the ECOLEAD project,

*“In ten years, in response to fast changing market conditions, most enterprises and specially the SMEs will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations.”*  
([www.ecolead.org](http://www.ecolead.org))

The message that this quote delivers could be applied to organisations as well as to individuals wishing to prosper and succeed.



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## **Appendices**

### **Appendix 1 Fulfilling EngD requirements**



The work undertaken within this research provided the author the means for demonstrating that the requirements for the engineering doctorate are met. In the following paragraphs the way and the extent these requirements have been met are discussed.

- Significant contribution to an industrial business: The vast majority of companies still continue to rely on old trusted methods of doing business even though outsourcing to lower cost regions and countries is a major threat to many engineering SMEs in Europe. E-Business take-up and success in Europe among engineering businesses is low. There are successful, well-documented case studies that demonstrate the level of benefit that can be achieved (Cisco, 2001a) but considering the level of investment; overall achievement is still relatively modest. The concepts developed in this research, based around recognising that engineering SMEs are not defined by their existing products, but by the capability and skills they possess, contribute to an alternative view about the reasons for failure of many SME e-business take-up initiatives.

The Northern Defence Industries (NDI) has claimed that with the implementation of the CPM, enquiry processing will be improved as well as the quality of information regarding the abilities of its members. It has also stated that this application will have a significant positive impact upon the region's defence and aerospace community. As a result of this faith, the company has recruited a full-time permanent project manager to undertake the task of successfully implementing CPM and managing the process of assembling effective collaborations among engineering companies (*Appendix 2*).

Being a larger experiment, the WMCCM provides evidence of CPM's direct contribution to the performance of engineering SMEs. WMCCM's objectives for the profiled SMEs are set to be as follows:

- 10% increase in sales generated by SME e-commerce
- 5% increase in the number of SMEs exporting
- 15% increase in the numbers involved in electronic collaborative relationships
- 5% increase in the number of new product launches
- 10% reduction in transaction costs

The project has already demonstrated some real benefits from the results achieved so far:

1. Local, national and international visibility of what profiled SMEs can do has increased. This has resulted in, on average, a doubling of the number of enquiries they receive.
2. Identification of SMEs by their competences has enabled them to consider alternative work prospects and take action. Over 40,000 tenders have been automatically sent to SMEs that are categorised and identified by their competences. There is direct evidence of over £0.5 million of increased sales as a result.
3. Engineering SMEs are considered for partnership in complex multi-partner projects. There are over 100 collaborative work spaces being utilised by companies to help design products and co-ordinate collaborative projects.



In addition, the work had a significant contribution to the performance of the MAS-WM. Early comparative information indicated that the MAS-WM was one of the most successful regional MASs (see *Appendix 3*). Almost 50% of all in-depth MAS consultancy projects in the UK derived from the MAS-WM. The service has also the most ‘referrals to other services’ related to the involvement of external specialists.

- Innovation in the application of knowledge: Novel applications have been created for enabling collaboration as well as the identification and presentation of competences. More detailed description of the novel features of these applications is provided in a following section (*6.5 Innovation summary*).
- In-depth analysis at the outset of alternative options and analysis of the extent to which objectives were met: Analysis of the alternative options has been conducted through various methods such as bibliographical research, discussions with experts and visits to exhibition/conferences. Effective solutions have been identified to meet the requirements identified in all cases. The way and the extent to which the objectives of this research have been met are discussed in detail in paragraph 6.3 (*Meeting the research objectives*).
- Possibility of wider publication: The ideas incorporated in this research project:
  - have been presented and incorporated in the proceedings of the Engineering Doctorate conference at the International Manufacturing Centre, Warwick University (Armoutis, 1999). The conference attracts more than 100 attendees every year both from the academic and practitioner’s community in the UK.
  - have been peer reviewed and presented in the ‘International Journal of e-Business Strategy Management’ (Armoutis and Bal, 2001a).
  - have been presented in the ‘e-now’ conference organised by the ‘Regional IT Association’ (RITA) in the West Midlands. Over 150 individuals attended this conference representing a wide range of engineering companies as well as business support organisations.
  - have been presented with a poster presentation and incorporated in proceedings of the Engineering Doctorate conferences at the International Manufacturing Centre, Warwick University (Armoutis and Bal, 2001b).
  - have been presented and incorporated in proceedings of the European conference ‘e-Challenges’ (Armoutis and Bal, 2003; Bal and Armoutis, 2005). E-Challenges is sponsored by the European Commission and the Information Society. The conference attracts over 500 delegates from commercial, government, and research organisations around the world.
  - have been incorporated in the proceeding of the ‘European Concurrent Engineering Conference’ (Baguley et al., 2004). The conference is targeted at industrial enterprises, industrial associations, universities and research institutes attracting over 200 delegates every year.
  - have been presented and incorporated in the proceedings of the Research Day conference at the School of Engineering, Durham University (Armoutis, 2004). This annual conference attracts more than 100 academics and industrialists across the UK.
  - have been incorporated in the proceedings of the ‘Manufacturing, Modelling, Management and Control’ conference (Maropoulos and Armoutis, 2004). This



annual conference is organised by the International Federation of Automatic Control (IFAC). IFAC is a worldwide organization that addresses professionals, theorists, engineers, and researchers. Its conferences are technically monitored by International Program Committees, which subject draft papers to a rigorous reviewing process.

- have been incorporated and presented in the proceedings of the ‘International Conference on Changeable, Agile, Reconfigurable and Virtual Production’ (Armoutis et al., 2005). This is a high profile conference supported by key industrial players such as the BMW group, Siemens, and the Boston Consulting group.

As far as the development of the author’s personal competencies is concerned, the following were achieved:

1. Expert knowledge within the field of the supply chain engineering in the manufacturing sector. To identify suitable solutions that would meet the identified requirements, a deep understanding of supplier evaluation and appraisal leading to competence identification and appraisal was required. This competence was gained through activities such as:
  - Bibliographical research into theories and practices in supplier evaluation and appraisal as well as into competence identification and appraisal
  - Making contacts with experts within and outside of the projects such as Mr Michael Szczygiel from the European Automotive Initiative Group. Michael has many years of experience in ICT implementation projects and has interviewed over 150 engineering SMEs in the West Midlands
2. Appreciation of the industrial engineering and development culture. This competence was gained through tasks such as:
  - Visiting, interviewing, observing, and analysing the information collected from over ninety engineering SMEs and manufacturing related research groups.
  - Participating in engineering SME development projects such as the Autocle@r and the Autolean 3

Such activities provided the author an opportunity to improve his understanding of various types of culture in industry. For instance, after extensive interactions with engineering SMEs, the existence of two categories of companies became apparent:

1. Companies that were really keen in exploring new ways of working
2. Companies that were only looking at the opportunistic benefit that the development projects were offering such as the provision of free virtual teaming kit

In contrast with the second category, companies in the first category made serious effort in applying the recommended solutions. They were looking at competence profiling as an opportunity to explore, and thus were keen to provide their information to the project team. In some cases this keenness resulted in the establishment of good relationships with the Warwick Manufacturing Group leading to new collaborations on further projects. Examples of such companies are Frederick Woolley Ltd and Richmond Design & Marketing Ltd.



3. Skills in managing, planning, control, and financial engineering projects as well as in leading and guiding others to meet objectives. Example of tasks that provided the author with the chance of improving his financial engineering and project planning and control skills are:

- Activities planning and funding allocation for the Autolce@r project
- Activities planning and cost breakdown for the MAS-WM project

In addition, the following leadership and project managing roles were undertaken:

- Competence profiling project in Autocle@r
- Competence profiling project in Autolean 3
- Expertise profiling in MAS-WM

The author had the opportunity to learn through real-life experience the difficulty of managing and leading changes and in particular the significant role that social, human, and organisational factors play during these changes.

4. Ability to work effectively within teams. Teamwork skills were also required in many tasks. For instance:

- A project team was formed for the development of MAS-WM processes consisted of four core members: the author, Dr Jay Bal, Dr John Garside, and Mr David Hall.
- For the implementation of the Expertise Profiling Methodology (EPM) a team was created with key members of: the author, Dr Dudley Wood from the NB2BC, Mr Peter Roach representing the MAS-WM, and Dr John Robson from the CONTACT.

Working closely with other individuals, it was realised that:

- Mixing and matching effectively skills is a key success factor for a team. For instance, during installation of the Competence Profiling Facility and the Expertise Database the author worked closely with Mr Chun Wea Chang. Chun has superior skills in systems configuration and integration which complemented the author's ability to plan projects and communicate with project members.
- Teamwork provides a key opportunity in improving personal skills by following team members' leads. For instance, working closely with Dr John Garside, the author improved his ability in addressing political issues and in being persuasive.

5. Communication skills, both oral and written. Written communication skills were progressively improved via the development of various documentation such as:

- project reports
- publications
- submissions

In addition, oral communication skills were improved via participation at many events. Example of such events are:

- project meetings and workshops such as the MAS-WM 'Operational Standards Identification' workshops
- demonstrations and presentations of the developed solutions and their results to conferences, project partners and other interested organisations (e.g. Advantage West Midlands)



6. Skills in technical organisation. Technical and organisational skills were developed through the use of a variety of methods and software tools during project activities such as:
  - The development of relevant facilities. For instance, website and database design using Dreamweaver Ultradev and MS Access was required.
  - The planning and control of the project. This was assisted by the use of MS Project and MS Excel.
7. Ability to apply skills and knowledge to new unusual situations. The development and implementation of the solutions provided the author with the opportunity to apply knowledge and skills to new and unusual situations. Examples of such new and unusual situations are:
  - Developing and implementing e-business solutions
  - Working closely with UK engineering SMEs
  - Being involved in a publicly funded project with large partner organisations such as Unipart, GKN, Sun Microsystems, and BT
8. Ability to search relevant information sources and seek optimal and viable solutions to complex engineering problems. This competence was developed via activities such as:
  - a) Conducting bibliographical research through on-line resources (e.g. Pro-Quest) and building relationships with experts
  - b) Creating engineering SME competence catalogues
  - c) Assisting the process of identifying appropriate expertise providers for engineering SMEs
  - d) Developing and implementing the Competence Profiling Facility and the Expertise Database

Although ‘seeking optimal solutions’ is a key requirement of the EngD, the meaning of the term ‘optimal’ may be open to discussion. The term has a clear and explicit meaning within the scope of quantitative decision modelling. It is the ‘very best’ identified after defining an objective function that is maximized or minimized when considering measurable outcomes such as profit, speed of service, and cost (Zeleny, 1982; Taha, 2003). In this respect, this research has put into practice optimisation by utilising the linear weighted method to identify and suggest groups of companies to undertake a specific project (paragraph 4.4). Although ‘optimal’ may be explicit in mathematical terms, it may be less explicit from a more social perspective. This research and solutions developed, such as CPM, are directly linked with the natural social environment. When making decisions and solving complex business problems within a natural social environment, there are many qualitative and immeasurable factors and constraints such as cultural, political, and legal which mandate human judgement. Technology has improved a lot and, as argued by Bonabeau (2003), powerful decision-making tools can help decision makers quickly sort through vast numbers of alternatives and pick the ‘optimal’ ones. However, all these tools make use of human judgment, experience, and perception which add subjectivity to decision making and problem solving. For this reason ‘optimal’ solutions identified will always be subjective and therefore, more likely to be ‘favoured’ solutions according to individual perceptions.



## **Appendix 2** NDI vacancy adverbs



### Business Opportunities — Can YOU help?

The MoD is asking for expressions of interest for the engraving of approx 55,000 ID/Medical tags per annum.

There is a requirement to procure approximately 28 hand held Ultrasonic leak detectors suitable for detecting leaking valves and 28 hand held (very portable) RVI cameras that can be used in confined areas of submarines.

MoD has Submarine Requirements to 1st Level Quality Assurance for steel pipe work involving cutting, welding and pipe bending.

Interested? Contact Gary on 0191 516 6680 or by email [gary.scott@ndi.org.uk](mailto:gary.scott@ndi.org.uk)

### NDI JOB VACANCY Project Manager — Prime Contractors and Suppliers

NDI has a vacancy for a Project Manager who will be responsible for the management and development of NDI's relationship with Prime Contract clients, the assembly of clusters/teams of suppliers, assessment of suppliers and the management of communications between NDI/Primes and suppliers.

The successful candidate should be a qualified engineer/manager with experience of supplier management and who has good business skills and an entrepreneurial attitude.

A job specification is available from Maria Connelly who can be contacted on 0191 516 66 80 or email [maria.connelly@ndi.org.uk](mailto:maria.connelly@ndi.org.uk).

We wish to make an appointment as soon as possible, CV's should be sent to Maria Connelly by Friday 21st May.

### Selling to the USA — a date for your diary ...


On the morning of THURSDAY 24th JUNE, an event to highlight the opportunities and complexities of the vast USA defence and aerospace markets is to be held.

The event will include:

- current state of Defense and Homeland security and the impact of Iraq on available funds
- case studies of successful UK/European product/technology sales to the US Government
- specific products and technologies in demand
- specific laws and procedures related to the export of technical information to the US Services available to NDI members

**VENUE AND AGENDA TO BE CONFIRMED SOON — WATCH THIS SPACE!**



	<h1 style="text-align: center;">NDI BULLETIN</h1>	<b>Volume 3: Issue 7</b>
		<b>08 April 2005</b>

## SUPPLIER NETWORK MANAGER

**A JOB OPPORTUNITY WITH NDI:** NDI matches the supply capability of its member companies with the procurement requirements of the Ministry of Defence and the global defence, aerospace and naval industries. We wish to recruit a 'Supplier Network Manager' who will be at the heart of these activities and to assist us with our ambitions for future growth and development.




The successful candidate will be mobile, have a passport and driving license and will have experience in engineering and manufacturing, in project management, in profiling, assessing and developing suppliers, and will be capable of communicating at all levels of industry including senior staff in prime contractors and the MoD.

NDI is looking for creative contribution to its team from an individual who has grasped the issues of supply chain collaboration and cooperation and who can identify, develop and articulate creative solutions for the out-sourced manufacturing models that prime contractors are increasingly implementing.

The post attracts a salary that reflects the importance of the role: full details/job specification available from Maria on 0191 516 6680 or [maria.connelly@ndi.org.uk](mailto:maria.connelly@ndi.org.uk)

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## **Appendix 3** Comparison of regional Manufacturing Advisory Services



The table below provides an overview of level 1 to 5 activities from the start of the MAS to 30 June 2003 conducted by the regional MAS centres. It is part of a draft report provided by the National Network Development Team.

Region	South West	North West	North East	Yorkshire and the Humber	West Midlands	East Midlands	South East	East	London	Wales	Totals
Level 1	858	5574	627	2795	1876	544	2017	103	676	507	15577
Helpline							1627		126		30183
Website	13320				7002		9313		548		
Level 2											
Day Diagnostic Visit	307	322	209	380	726	424	416	18	129	493	3424
Level 3											
Events and Workshops	100	29	39	35	21	33	99	16	62	9	443
Attendees	6548	1587		1719	366	1454	2534	349	452		15009
Level 4											
In depth Consultancy	108	59	71	121	508	33	76	5	22	18	1023
Completed projects		34		48	338						420
Level 5											
Referrals to other Services	280	335	39	78	430	26	586	9	117	83	1983
BL	118	10		31		2	149		17		327



The table below provides an overview of level 1 to 5 activities to the end of December 2003 conducted by the regional MAS centres.

Region	South West	North West	North East	Yorkshire and the Humber	West Midlands	East Midlands	South East	East	London	Wales	Totals
Level 1 Helpline	1356	2429	915	3184	2283	774	3276	1014	1619	754	17604
Website	49928	5238		10	16071	24	1627	3006	126		1753
Level 2 Day Diagnostic Visit	483	530	305	798	1070	636	583	117	228	672	92482
Level 3 Events and Workshops	126	38	61	39	38	45	167	28	139	21	702
Attendees	6895	1902		2024	802	1909	3986	836	1928		24
Level 4 In depth Consultancy											20282
On-going		26		82	48						156
Completed	116	56	93	115	469	96	121	26	51	39	1182
Level 5 Referrals to other Services	371	350	57	92	778	36	775	32	250	217	2958
BL	177	10		30	121	4	219	15	57		633

(Source: Report of Activities (DTI-MAS, 2004))



## **Appendix 4** The Competence Profiling Questionnaire



Key Indicators

Company Name		
Address		
Telephone		
Fax		
Web Site		
Contact Person		
E-Mail:		
Basic Line of Business	e.g. Specialist Applications of Pre-Treatments and Powder Coatings	
Key Markets		
Products and Services		
Products or operations regarded as:	Runners	
	Repeaters	
	Strangers	
Number of Employees		
Annual Turnover		
Rate of growth		

Notes:

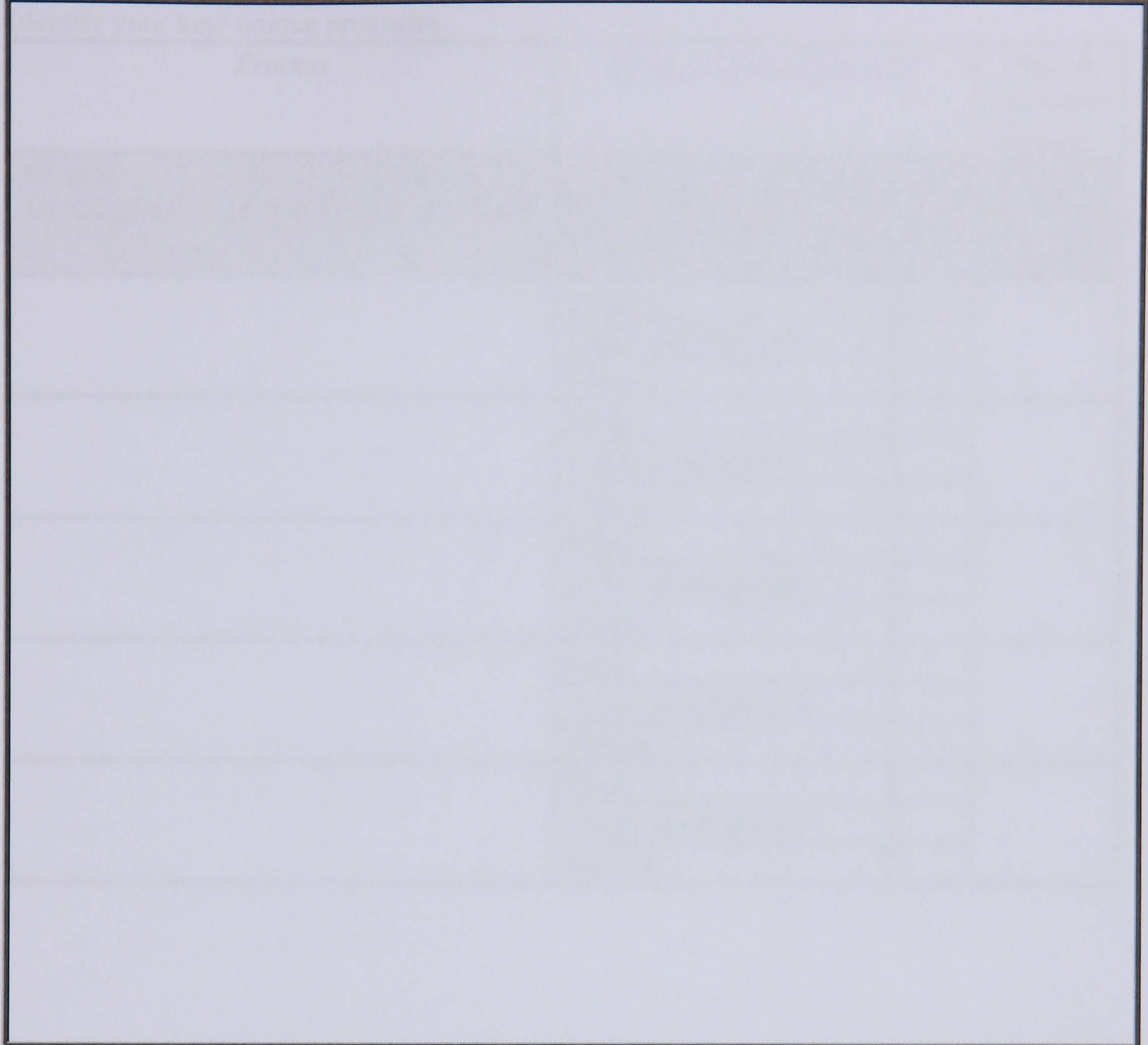
Mission statement:

Four key points:

- The way customers are treated
- The way business is done
- The way people are paid
- The way the company is run



## Company Ethos

**Notes:**

Mission statement.

Possible key points:

- The way customers and employees are treated
- The way business is done
- The way people are trained
- The way that attention to detail is given



Processes

Identify your key/ unique processes

<i>Process</i>	<i><u>Level of Process Mastery</u></i> <sup>2</sup>		<i>Time in operation (years)</i>
<b>Example</b> Thermoplastic injection moulding +2 shot	Basic		2
	Under development	X	
	Mature		
	Basic		
	Under development		
	Mature		
	Basic		
	Under development		
	Mature		
	Basic		
	Under development		
	Mature		
	Basic		
	Under development		
	Mature		
	Basic		
	Under development		
	Mature		

<sup>2</sup> *Basic*: A process that the company has only basic understanding. It may be relatively new to the company and there is only little experience.

*Under Development*: A process not fully grown in the company. It is still been learned.

*Mature*: A process not subject to major changes. It is a routine for the company.



People

Identify your key people and their skills

<i>Position</i>	<i>Skill</i>	<i><u>Level of skill</u></i> <sup>3</sup>		<i>Years of practice</i>
<b>Example</b> Operations Director	Application of powder coatings to porous material	Certified	X	30
		Experienced	X	
		Certified		
		Experienced		
		Certified		
		Experienced		
		Certified		
		Experienced		
		Certified		
		Experienced		
		Certified		
		Experienced		

Notes:

Question

Who are the key people in your company and what skills do they have? Please specify one from each of the following areas:

- Quality
- Production
- Engineering
- Quotation/Project management
- Other

<sup>3</sup> *Certified*: Somebody that has met the knowledge conditions or requirements to become accredited for or entitled to a position or privilege.  
*Experienced*: Somebody with less accredited knowledge. It is been acquired through involvement in to something over a period of time without any accreditation associated with it.



**Competence Transfer**

Identify products or services and market sectors that you foresee transferring to. Provide case histories.

<i>Products or Services</i>

**Notes:**

Question

Do you foresee products or services that you can possibly transfer to? Which industrial or market sectors are they aiming for? Describe also case histories of transferring to different sectors.



Qualifications

Awarded Standards	QS9000	
	ISO9001	
	ISO9002	
	ISO9003	
	ISO14001	
	Other	
Mechanisms to ensure continuous improvement		
Reference Customers	Customer: supplying to:	
	Customer: supplying to:	



**Appendix 5** The Competence Profiling Methodology  
Assessment Form



Competence Profiling Methodology Assessment Form

Company Name: NORTHERN DEFENCE INDUSTRIES LTD

Address: BUSINESS & INNOVATION CENTRE, SUNDERLAND

Contact Person: GARY SCOTT Title: OPERATIONS MANAGER

Phone: 0191 5166680

E-mail: GARY.SCOTT@NDI.ORG.UK Web Site: WWW.NDI.ORG.UK

Please indicate the degree of usefulness of the Competence Profiling Methodology with respect to each of the following statements. That is, how useful is the methodology in terms of:

(0 = non, 1 low, 2 = medium, 3 = high)

1. Allowing access to information about an engineering company's abilities by potential local, national, and international customers	0	1	2	3
Comments?				✓
2. Considering engineering SME's for partnership in complex multi-partner projects	0	1	2	3
Comments?				✓
3. Enabling buyers to electronically search, compare, and match new alternative sources of supply	0	1	2	3
Comments?				✓
4. Enabling buyers to identify a suitable supplier or group of suppliers by their key abilities	0	1	2	3
Comments?				✓
5. Providing engineering SME's with the ability to apply their competences in fields or locations that may be more profitable	0	1	2	3
Comments?			✓	



6. Providing the ability to map the skills and capabilities of a region/sector

Comments?

0	1	2	3
			✓

7. Speeding up the process of selecting suppliers/partners

Comments?

0	1	2	3
			✓

8. Reducing uncertainty in selecting suppliers

Comments?

0	1	2	3
		✓	

9. Ease of use of its associate system

Comments?


0	1	2	3
		✓	

Other

0	1	2	3
0	1	2	3

Please provide your overall comments

All of the above points are very important to Northern  
Defence Industries. NDI promotes the capability of its  
membership to the Global Defence & Aerospace Industries  
and it is essential that we understand the strengths &  
weaknesses of the supply chain.





## **Appendix 6** Participated by the author WCCM Workshops



The author had many interactions with, and provided consultation to the WMCCM project team including system integrator Syntegra. The team consisted of Dr J. Bal Program Director, Mr A. Gegios Project Manager, and M. Swift Technical Lead Consultant. At the development stage he also advised Syntegra, the company allocated with the task of developing the system (Mr P. Cowen Technical Design Authority). The consultation and advice provided ensured successful application of the concepts and ideas involved in the competence profiling. It also assisted in integrating effectively new ideas and making changes required for this new implementation. The effectiveness of the development has been assessed through two key workshops (agendas provided below).

Focusing on CPM, the feedback received from these workshops was generally regarded positive. Key engineering SME representatives, such as D. Keen (Director) from Richmond Design and Marketing Ltd and T. Dodd (Operations Manager) from Frederick Woolley Ltd, stated that they were comfortable with finding partners and forming partnerships through the system. The importance of having criteria which would indicate the familiarity of a supplier/partner with a particular type of supply chain or sectors was identified. Other comments stressed the importance of having a process, such as the 'normalisation' process in CPM, for validating the competence information provided and ensuring that it is up-to-date.





**Agenda for WMCCM 2<sup>nd</sup> Workshop**  
**on Thursday 15<sup>th</sup> May 2003 at 10:00am**

**Location:** WMG Offices, The University of Warwick

<b>Attendees:</b>	Dr Jay Bal	WMCCM Programme Director
	Alex Gegios	WMG Project Manager
	Mark Swift	WMG Technical Lead Consultant
	Nikos Armoutis	WMG Technical Consultant
	Tom Dodd	Frederick Woolley Limited
	David Keene	Richmond Design & Marketing Ltd
	Steven Martin	BlueSoft Ltd
	Andrew Woolley	Woolley and Co Solicitors
	Brian Harvey	Clamonta Engineering Co Ltd
	Malcolm Davies	Syntegra Manufacturing Sector Consultant
	Peter Cowen	Syntegra TDA
	Raj Lakhani	Syntegra Project Manager

**Agenda:**

**Part 1**

1. Background/Introduction (Alex)
2. Review/Agreement of Workshop Objectives (Malcolm)
3. Demonstration of: (Peter)
  - Tender functionality
  - Partner search
4. Feedback (All)
5. Demonstration of: (Peter)
  - Project Collaboration Capability (i.e. allowing companies to collaborate on engineering design projects and provide basic functionality to enable this collaboration)
  - SME Clustering Capability
  - Community Facilities
    - Bazaar
    - News
    - Discussion Lists
6. Feedback (All)
7. Lunch





**Agenda for WMCCM 3<sup>rd</sup> Workshop**  
**on Friday 25<sup>th</sup> July 2003 at 10:00am**

**Location:** WMG Offices, The University of Warwick

<b>Attendees:</b>	Dr Jay Bal	WMCCM Programme Director
	Alex Gegios	WMG Project Manager
	Mark Swift	WMG Technical Lead Consultant
	Nikos Armoutis	WMG Technical Consultant
	Yvette James-Gordon	WMG Research Engineer
	Tom Dodd	Frederick Woolley Limited
	Steven Martin	BlueSoft Ltd
	Alan Shaw	Regent Engineering Ltd
	Mike Szczygiel	EAIG Ltd
	John Walkerdine	Interserve Ltd
	Brian Miles	Innovation Direct
	Malcolm Davies	Syntegra Manufacturing Sector Consultant
	Paul Hayman	Syntegra Manufacturing Sector Consultant
	Peter Cowen	Syntegra TDA
	Raj Lakhani	Syntegra Project Manager

**Agenda:**

**Part 1**

1. Background/Introduction (Alex)
2. Review/Agreement of Workshop Objectives (Malcolm)
3. Quick Update on: (Mark/Alex)
  - Tender functionality
  - Partner search
4. Demonstration of: (Mark/Alex)
  - Project Collaboration Capability
  - SME Clustering Capability
  - Community Facilities
    - News
5. Demonstration of: (Peter)
  - Discussion Lists
  - Bazaar
  - Auctions Capability
  - Cataloguing Capability
6. Feedback (All)
7. Lunch



**Appendix 7** The Associate Profile Form



Name of associate organisation:

Main contact:

Telephone:

Telex:

Email:

Website:

## Associate Profile Form



Compiled by:

Peter Roach  
Iain Robertson  
John Robson  
John Garside  
Nikos Armoutis

July 2003



**Name of associate organisation:**

**Main contact<sup>4</sup>:**

**Telephone:**

**Telefax:**

**Email:**

**Website:**

**1. Industrial sectors served by people in your organisation (Please indicate with "X"):**

Aerospace	
Automotive	
Building products	
Ceramics	
Chemicals and pharmaceuticals	
Communications, electronics, computing	
Food	
General manufacturing industry	
Jewellery	
Medical equipment	
Plant, machinery and equipment	
Railways, off road, and marine	
Services/Consultants	
White goods	
Other (please specify)	

<sup>4</sup> It refers to the individual who provides the information for this form. If different from this, you may also provide contact details of a person who may have an overview of the organisation's operations and can deal with enquires.



2. Please specify the technologies in which your organisation has particular expertise and the size of team available to support clients in each area<sup>5</sup>. It would also be useful to know the name of your leading expert for each of the activities.

Technologies		
	Staff	Expert
<b>Materials</b>		
Ceramics		
Chemicals		
Coating		
Composites		
Ferrous metals		
Non-ferrous metals		
Glass		
Plastics		
Special alloys		
Wood / Paper		
<b>Manufacturing Processes</b>		
Assembly / Test		
Cutting / Grinding / Machining		
Electronic assembly		
Fabrication / Welding		
Forging / Pressing / Extrusion / Casting		
Heat treatments / Plating / Painting / Coating		
Packaging		
Robotics / Automation		
<b>Other Technologies</b>		
Communication/ Data process / E-commerce		
Control / Mechatronics / A.I.		
Electronics & Sensors / Laser / Optics		
Fluid / Thermodynamics		
Food and drinks		
Nanotechnologies		
Power generation / Storage		
Rapid prototype		
Textiles		

<sup>5</sup> Each part-time employee counts for 0.5.



Please specify the business processes and/or services in which your organisation has particular expertise and the approximate size of team available to support clients in each area<sup>6</sup>. It would also be useful to know the name of your leading expert for each of the business activities.

Business Processes		
	Staff	Expert
Aftermarket support		
Business planning		
Business development		
Customer satisfaction and quality		
Industrial distribution		
Marketing		
Manufacturing practice		
People and organisations		
Process innovation		
Product introduction		
Project management		
Sales		
Supply chain management		

Services		
	Staff	Expert
Accounting / Costing		
Environmental / Green		
Health and safety		
Industrial design		
ICT		
Lean principals		
Logistics		
Maintenance		
Process capability / 6σ		
Quality / Accreditation		
Research and development		
Test / Evaluation		
Tooling		
Training / Staff development		

<sup>6</sup> Each part-time employee counts for 0.5.



3. In the following table, please specify your core facilities and equipment that could be used to support clients<sup>7</sup>.

	<i>Activity<sup>8</sup></i>	<i>Facilities and equipment supporting this activity.</i>	<i>Age of facilities</i>	<i>% of time currently available</i>
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

<sup>7</sup> e.g. Activity: *Injection Moulding* - Facilities and Equipment: *30 and 50 tonne micro-processor controlled thermoplastic injection moulding machines*. You may group them in case a large amount of facilities/equipment exists (e.g. Activity: *Robotics* - Facilities and Equipment: *12 industrial robots. Capacity 2 to 150 kgr*).

<sup>8</sup> You may see classification in section 2.



4. In the following table please specify initiatives that exist in your organisation and are able to fund further projects following on from an MAS-VM introduction.

	<i>Name of the initiative</i>	<i>Brief description</i>	<i>Source of funding</i>	<i>Expiry date</i>
1.				
2.				
3.				
4.				
5.				



**Appendix 8** The key changes made to the Associate Profile  
Form



Attempting to find a solution a team was formed consisting of the author, Dr J. Garside from Warwick Manufacturing Group, Dr J. Robson from CONTACT, and Mr P. Roach from MAS-WM, Mr I. Robertson Specialist Manufacturing Advisor from MAS-WM, and Ms T. Burns Technology Diversification Manager from the Defence Diversification Agency (DDA) West Midlands. DDA is a Government initiative and its main responsibility is to widen the use of publicly-funded defence technology. It does that by spinning out defence technology to civil sectors including manufacturing. DDA in the West Midlands is an expertise provider to MAS-WM. Due to the wide range of technologies DDA deals with, Ms T. Burns was regarded by the team as the technology expert. In addition, together with Dr J. Garside, Ms T. Burns provided input from the expertise providers’ perspective. The team met on 21 May 2003. Based on the existing form (available at Appendix 4 in Submission 3) a new simpler and shorter version of the Associate Profile Form was developed. The key changes made to the form were as follows:

- The sections ‘contacts in organisation’, ‘personnel’ and ‘skills’ in the older version were consolidated in a single section in the newer version. This newer section allows providers to select activities they are involved from three classifications provided (*Table 1, Table 2, and Table 3*).

**Table 1 Technology classification in the new Associate Profile Form (APF)**

Materials	Manufacturing Processes	Other Technologies
Ceramics	Assembly / Test	Communication/ Data process / E-commerce
Chemicals	Cutting / Grinding / Machining	Control / Mechatronics / A.I.
Coating	Electronic assembly	Electronics & Sensors / Laser / Optics
Composites	Fabrication / Welding	Fluid / Thermodynamics
Ferrous metals	Forging / Pressing / Extrusion / Casting	Food and drinks
Non-ferrous metals	Heat treatments / Plating / Painting / Coating	Nanotechnologies
Glass	Packaging	Power generation / Storage
Plastics	Robotics / Automation	Rapid prototype
Special alloys		Textiles
Wood / Paper		



**Table 2 Business processes classifications in the new Associate Profile Form (APF)**

Aftermarket support
Business planning
Business development
Customer satisfaction and quality
Industrial distribution
Marketing
Manufacturing practice
People and organisations
Process innovation
Product introduction
Project management
Sales
Supply chain management

**Table 3 Ancillary services classification in the new Associate Profile Form (APF)**

Accounting / Costing
Environmental / Green
Health and safety
Industrial design
ICT
Lean principals
Logistics
Maintenance
Process capability / 6σ
Quality / Accreditation
Research and development
Test / Evaluation
Tooling
Training / Staff development

- The classifications were based on the classifications for technologies, business processes, and services developed in the older version. These were filtered and aligned to meet the region’s requirements. For instance, in technologies emphasis was assigned to materials such as ceramics and manufacturing processes such as fabrication and welding in which (according to the advisors) this region has long tradition. For each selected activity the size of team available to support clients may be specified. This provides an indication of the likelihood for prompt response by the provider. In addition, an expert’s name may be provided for each of the specified areas of expertise. This was seen as an alternative contact from the main contact provided at the initial section of the form. As discussed in this submission, depending on the structure of the organisation different type of people may handle requests such as people with technical expertise or people like Industrial Liaison Officers (ILOs) who act as intermediaries. The form needed to address all cases.
- ‘Summary of activities, ‘key clients served’, and ‘values and qualifications’ were regarded as extra information which may be too exhaustive and demanding for many



providers. They were removed. Activities were clearly defined by the classifications developed (*Table 1*, *Table 2*, and *Table 3*) and as a result there was no need for summary activities. Although not flexible, classifications were seen as an easier method for mapping expertise, both for providers and advisors. Advisors can trace and compare expertise more easily than in a free text format. Soft issues in the newer version are mainly addressed by the refined industrial sector classification (*Table 4*).

**Table 4 Industrial sectors classification in the new Associate profile Form (APF)**

Aerospace
Automotive
Building products
Ceramics
Chemicals and pharmaceuticals
Communications, electronics, computing
Food
General manufacturing industry
Jewellery
Medical equipment
Plant, machinery and equipment
Railways, off road, and marine
Services/Consultants
White goods
Other (please specify)

Industrial sectors do not simply reflect on the matrix of MAS-WM services (paragraph 5.4.2 *Expertise Profiling Methodology (EPM)*), but indicate a providers familiarity with a particular industrial culture.

- The ‘access to funding sources’ was regarded having particular importance. The executive director of the MAS-WM, Mr D. Wright, stated 75% of enquires addressed by external providers lead onto further projects. Therefore, ‘access to funding sources’ was expanded and promoted to a separate section within the new version (section 4). This section asks providers to list initiatives that exist in their organisation that are able to fund further projects following on from an MAS-WM introduction. Accompanied by a brief description of the initiative, this list also enables providers to describe their specialised services. In addition, the list highlights the validity and applicability of the expertise available, a key component of the competence definition.



## **Appendix 9** Further developments on expertise profiling



The author maintained contact with MAS-WM and participated in regular reviews of operations. Other attempts to address the issues associated with identifying sources of appropriate expertise have come to light such as the Oakland guides of UK 'University Expertise and Facilities' and the 'Knowledge House' deployed in the North East. More details of these solutions are provided in *Appendix 10*.

A meeting with key individuals involved in the development and operation of the MAS-WM service was organised on 7 May 2003. The meeting attempted to identify the obstacles causing late adoption. Participants were the author, Dr J. Garside from the Warwick Manufacturing Group, Dr J. Robson from CONTACT, and Mr P. Roach from MAS-WM. The two main reasons claimed by the attendees were:

- The complexity of the Associate Profile Form. The form was regarded as being very long and the information it sought to capture as being very detailed.
- The inclusion of the Short Message Service (SMS) as a method of communication with providers. SMS was introduced as a pilot technology and conventional methods of communication could also be used, such as email and telephone. However, it was claimed that its inclusion caused concerns to many providers who were not familiar with this technology. The Expertise Database was closely associated with the SMS facility.

As a result, advisors and other individuals who attempted to promote the form and to capture the expertise available found it hard to convince providers to complete the forms. However, it was recognised that the existing approach of dealing with expertise providers that MAS-WM advisors knew and had contacts with was not sufficient. As Mr P. Roach from the MAS-WM claimed, only one third of enquires requiring external expertise could be handled in this manner. Another third were requests that advisors had a fair idea of where to search for expertise and the rest were 'one-off' types for which advisors did not know any source of appropriate expertise. It was also recognised that the existing approach employed by CONTACT was inefficient and slow. Sending all enquires unselectively to all expertise providers was causing excessive bureaucracy, irritation and confusion.

To find a solution the author led an attempt to restructure the Expertise Profiling Methodology. The key changes made were as follows:

1. Based on the existing form a new simpler and shorter version of the Associate Profile Form was developed (*Appendix 7*). The newer version brought in accumulated experience from the previous version as well as experience MAS-WM advisors had over the requirements of the service. Advisors had now more than one year experience in the MAS-WM and therefore had developed their understanding and knowledge of the service's operations and the special characteristics of the manufacturing sector in the region. The key changes made to the form are described in *Appendix 8*.
2. It was recognised that the success of Expertise Profiling Methodology (EPM) was based on the commitment of the advisors to promote the profile. The MAS-WM advisors, I. Robertson and P. Roach, agreed to committing themselves and the other advisors to interviews with providers, guided by EPM, to ensure that forms are properly and timely completed.



3. Regarding the fourth stage of the EPM which involves the method of job requesting, the idea of using SMS to contact providers was abandoned. The results of the pilot testing exercise had shown clearly that providers were not comfortable enough to accept such a technology. According to J. Robson from CONTACT, the organisation that did the pilot testing, none of the several attempts made succeeded in engaging any provider in an SMS dialogue.

The new profile form was presented by Dr J. Garside to all interested parties at an MAS-WM workshop on 17 July 2003. The form was generally well accepted. Attendees expressed their wish to have such a database available on-line through the Internet. Although limited, reservations were also expressed. These were related to the second section of the form where an expert for each of the organisational activities was nominated. It was argued that the MAS-WM should follow the existing structures and operations of the provider organisations and therefore use only the liaison officers, when those exist, as the point of contact on any occasion. These reservations proved once again that there were reasons beyond the obvious technical problems that caused significant delay in the adoption of the EPM. Political and social issues, risks to roles and responsibilities and perceived threats to jobs caused major problems. However, the stated commitment by the executive director of the MAS-WM in supporting the profiling of the region's expertise creates optimism about the future of the EPM. Expertise Database is considered as a regional database beneficial for both the service and regional policy makers.



## **Appendix 10** Oakland guides and Knowledge House



### **Oakland Guides**

At the UK national level the 'University Expertise and Facilities' is a series of guides devised and published by Oakland Consultancy. The guides were made available both in hard copy and in keyword searchable floppy disk format. One of these is manufacturing specific and provides summary profiles for a range of units and groups in universities. An example of a profile provided by this guide is shown in *Figure 1* and *Figure 2*.

Oakland profiles provide information on expertise and facilities available. However, no consideration for keeping this information up-to-date has been made. The guide was originally published in 1995 and since then no further updates have been made available. In addition, the guide was focused only on expertise available in universities and did not cover other Centres of Excellence in Manufacturing (CEMs), such as Colleges and other partnerships, which the MAS would also like to have access at. In the West Midlands, only three profiles out of a possible twelve in the region are available. These were Warwick Manufacturing Group (Warwick University), the School of Manufacturing & Mechanical Engineering at Birmingham University, and the School of Engineering at Coventry University. Profiles from groups in institutes such as Staffordshire University and Wolverhampton University that are available in the Expertise Database, do not exist in this guide.

### **Knowledge House**

At a regional level, 'Knowledge House' is another university focused solution deployed in North East. It is a service developed to assist businesses to find expert advice for developing ideas and solving problems. Emphasis is on the needs of the regional SMEs. 'UniManufacturing' is the manufacturing specific solution which provides access to expertise covering a range of manufacturing and related issues. Although not manufacturing specific, Knowledge House (at [www.knowledgehouse.ac.uk](http://www.knowledgehouse.ac.uk)) provides a simple on-line catalogues of expertise and facilities available at the region (*Figure 3* and *Figure 4*). These catalogues, however, are relatively basic. They do not provide any additional information such as the contact details of the institution that provides them or the key technical characteristics of the facilities such as capacity. After contacts the author had with Knowledge House representatives such as Mr Mark Jackson, the business development director, it was revealed that Knowledge House had already recognised the need for a more advanced expertise database and they were in a process of developing one. This new facility will be part of a newly introduced system, the 'Knowledge House Information System' (KIS). This expertise searching facility will be available to Knowledge House employees only and will assist the process of identifying appropriate expertise within the regional universities.



# THE UNIVERSITY OF WARWICK

## WARWICK MANUFACTURING GROUP

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### THE GROUP

Since its creation in 1980 by Professor S K Bhattacharyya, the Warwick Manufacturing Group has grown to be one of the largest groups of its kind in Europe. Some statistics (1995):

- Over 350 staff and industrial secondees.
- Generating activities worth more than £21m per annum, mostly funded by industry.
- Partnerships with over 300 companies world-wide in research and development, technology transfer and post-experience education programmes.
- Over 1000 participants on modular Masters programmes.
- Over 3000 other company staff on Diploma and other post-experience programmes each year.
- Major centres in Hong Kong, Malaysia, Thailand, India and six European cities.

Manufacturing industry is competing in a global market and international best practice is changing fast. Any university purporting to be assisting manufacturing companies must be familiar with the latest developments and knowledgeable of global trends. First-hand experience is essential. The Warwick Manufacturing Group has therefore set out to be involved with leading companies in Europe, in the Asia-Pacific Rim and in the USA, and has created a world-wide network of partnerships.

The focus for the Group's international activity is the new multi-million pound International Manufacturing Centre. It houses a Best Practice Unit which brings together all the knowledge gathered by the Group internationally and carries out its own global benchmarking studies. This ensures that the work done with partner companies takes account of the international state of the art.

### INTEGRATED MANAGER DEVELOPMENT PROGRAMMES

The Group has pioneered new ways of working with companies to define and deliver post-experience education. The academic-industrial partnership sets the objectives, determines content, jointly delivers the material, regularly reviews and updates it, and assesses participants through in-company project work.

This results in a programme which combines academic excellence with industrial relevance. It aims to develop executives and managers who can successfully handle the complexities of an engineering business. The elements listed below, therefore blend personal and vocational development in business skills, technological understanding and managerial capability at all levels.

#### ▼ Executive Awareness and Action Programmes

Modular courses; seminars, brainstorming sessions and operational audits tailored for a company's senior-level management.

#### ▼ Engineering Business Management and Process Business Management

Focused on the needs of manufacturing, engineering, engineering service, process and process-related companies, these

integrated programmes offer over 100 modules within the following schemes:

- Modular, part-time Masters degree schemes:

aimed at developing the leaders of change. Participants will typically be aged 25-35 with a degree or equivalent.

- Modular, part-time Post-experience Diploma: for existing managers who may not necessarily have formal qualifications.

- Engineering Doctorate (EngD): a pioneering Doctor's level scheme based on a blend of course work from the Masters scheme and a portfolio of industrially-orientated research projects.

- Short courses and dedicated programmes: to meet specific individual or company needs – including courses tailored from Masters or Degree modules, and skills courses. These courses can range from advanced management programmes such as Business Process Re-engineering to skills training in topics such as CAD/CAM and computer simulation of manufacturing.

Figure 1 Warwick Manufacturing Group profile in 'University Expertise and Facilities' guide (page 1)



# MAJOR RESEARCH AREAS

The Group's research is multidisciplinary and covers the range likely to be met in manufacturing industry, embracing both technological and operational innovation.

## TECHNOLOGICAL INNOVATION

Technological innovation is carried out in collaboration centres where state of the art facilities are provided by partner companies, and where company and university staff work together producing technology transfer by people transfer.

### ▼ Advanced Technology Centre

Created as a joint venture between the Manufacturing Group and Rover Group, projects undertaken in this Centre typically involve 40 companies from many product sectors, although the main focus is automotive and aerospace. The research programme centres on two themes: reducing the time and cost of new product introduction; and anticipating future environmental issues.

The Centre includes the Applications Engineering of Polymers Team, Rapid Prototyping and Tooling Centre, Low Emission Vehicles Team and many other technology-based research groups.

### ▼ Product Design Centre

The Group's CAD/CAM Centre is now established as the premier facility of its kind. It is fully integrated with the other research, teaching and management of change activities of the Group and is the principal focus of a product design capability embracing over 60 workstations. A direct link to the Group's Computer Integrated Manufacturing Cells enables a full response to all of industry's CAE needs. The Centre is an international CAD Educational and Production Services Centre.

### ▼ Computer Integrated Manufacturing Facility

Established with a dozen leading companies from Europe and the USA, it provides a real-world environment for teaching and research in CIM, factory communications and automation.

### ▼ Catalytic Systems and Materials Engineering

Research is developing new heterogeneous catalysts in the context of the overall reaction system. Much of the work is environmentally orientated. Extensive micro-reactor facilities are available supported by the latest surface analysis techniques such as XPS, AES, ISS, LEED, FTIR and VEELS.

Another research initiative is developing ceramic and ceramic composite materials from sol gel precursors. Extensive microscopy and property testing equipment is available to allow evaluation of sample materials.

### ▼ Materials and Processes

Materials and process research utilises extensive facilities for metals and polymers. For metals there is casting (conventional and metal matrix composites), conventional and laser machining, powder metallurgy, forging and forming. For polymers there is injection moulding, compression moulding, reaction injection moulding, spray lay-up and metal spray for tooling.

## OPERATIONAL INNOVATION

Operational innovation is carried out both within the Group's facilities and within collaborating companies using dedicated teams providing support in the following areas:

### ▼ Business Processes and Best Practice Units

Developing and using appropriate benchmarks to determine best practice globally, on business processes, technology processes, and change management.

### ▼ Operations Design and Simulation

Using a wide range of simulation software as well as knowledge engineering and CASE tools, the team builds predictive models of complex manufacturing or process operations and creates tools for scheduling and operational management.

### ▼ Logistics and Time Compression

A multi-company collaboration, developing new ways to measure and control the new product introduction process and the logistics performance of the complete supply and distribution chain.

### ▼ Quality and Reliability

A team developing the methodologies and tools with which companies can set meaningful quality and reliability targets and achieve them.

## LINKS TO TRAINING AND MANAGEMENT DEVELOPMENT

All of the above research activities provide facilities and case studies in support of the Group's post-graduate and post-experience education programmes. They are also used for demonstrations and hands-on training of company staff supporting the implementation of technologies, tools and techniques covered in the programmes.

## MANUFACTURING EXCELLENCE INITIATIVE

A dedicated programme for small and medium sized enterprises (SMEs). It provides facilitators to visit companies in order to understand their situation in some detail. There is a menu of support activities available so that a small company can benefit from the full range of the Group's courses and facilities. The Initiative is collaborative with European, national and regional agencies and includes a 'Breakthrough Technologies' programme which provides access to key emerging technologies which can make a step change in a company's competitiveness.



## KEYWORDS

- ▼ Automotive engineering
- ▼ Benchmarking
- ▼ Business processes
- ▼ Catalysis
- ▼ Engineering polymers
- ▼ Management development
- ▼ Post experience education
- ▼ Product design
- ▼ Rapid prototyping
- ▼ SME programmes
- ▼ Supply chains

Figure 2 Warwick Manufacturing Group profile in 'University Expertise and Facilities' guide (page 2)





Figure 3 The ‘expertise’ catalogue available at the Knowledge House web site



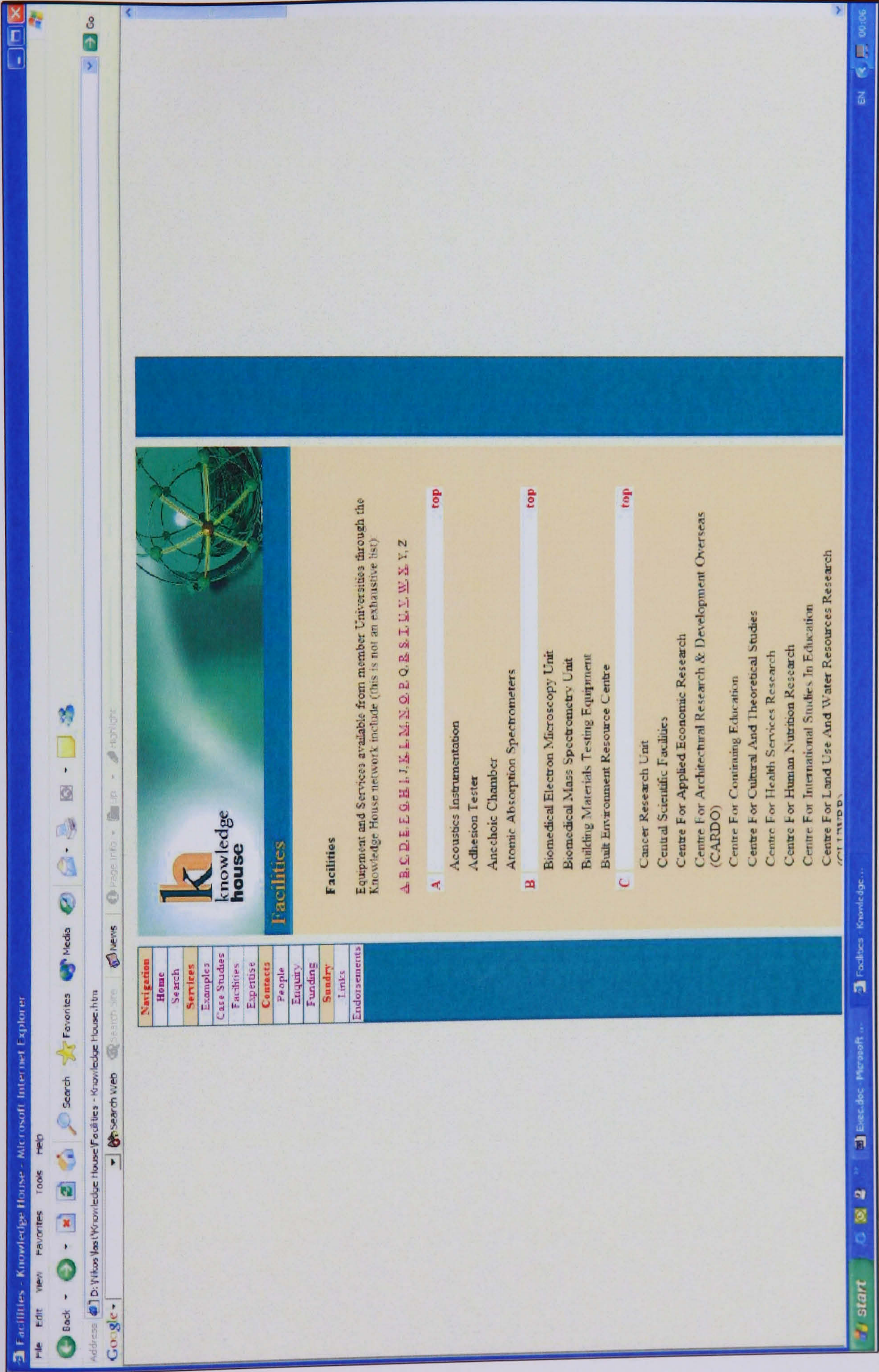


Figure 4 The ‘facilities’ catalogue available at the Knowledge House web site